R E P O R T

of the

INTERNATIONAL WHEAT-STEM-RUST CONFERENCE

held at
Fort Garry Hotel
Winnipeg, Canada
January 5-7, 1953

Plant Industry Station
Beltsville, Maryland
277CC--June 1953

FOREWORD

An International Wheat-Stem-Rust Conference was held at St. Paul, Minnesota, November 17-18, 1950, following the widespread occurrence of stem rust race 15B in the wheat-growing areas of the United States and Canada during the summer of 1950. On January 5-7, 1953, another International Wheat-Stem-Rust Conference was held at Winnipeg, Manitoba, Canada, in order to summarize research work, to facilitate the exchange of information, ideas, and materials, and to plan for future work. The proceedings of this latter conference are presented here.

Additional copies of this report may be obtained from the Division of Cereal Crops and Diseases, United States Department of Agriculture, Plant Industry Station, Beltsville, Maryland; the Laboratory of Cereal Breeding, Canada Department of Agriculture, Winnipeg, Manitoba, Canada; or the Rockefeller Foundation, Calle Londres 45, Mexico 5, D. F., Mexico.

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TABLE OF CONTENTS

TABLE OF CONTENTS--Continued

TABLE OF CONTENTS--Continued

TABLE OF CONTENTS--Continued

PROGRAM
WHEAT-STEM-RUST CONFERENCE
January 5, 6, and 7, 1953
Fort Garry Hotel
Winnipeg, Canada

Foreword - Wheat-Stem-Rust Conference

January 5	K. W. Neatby, General Chairman
9:00 A.M.	Opening Remarks
	Welcome Address
9:30-12:30 A.M.	Stem Rust Panel: E. C. Stakman, Moderator
	Panel Members: N. E. Borlaug, Helen Hart, E. B. Hayden, T. Johnson, C. V. Lowther, H. A. Rodenhiser, J. G. Dickson, G. J. Green
	1. What's new in prevalence and distribution of races?
	2. How virulent are they?
	3. How does environment affect their pathogenecity?
12:30-1:30	Lunch
	H. A. Rodenhiser, General Chairman
1:30-2:30 P.M.	Continuation of Stem Rust Panel
3:00 P.M.	Leaf Rust Panel: T. Johnson, Moderator
	Panel Members: J. F. Schafer, C. O. Johnston, M. N. Levine, A. M. Brown, B. Peturson
	1. What's new in prevalence and distribution of races?
	2. How virulent are they?
	3. How does environment affect their pathogenecity?
6:30 P.M.	Banquet - Courtesy of Canada Department of Agriculture Addresses by representatives of U. S. A. and Canada
January 6	R. F. Peterson, General Chairman
9:00 A.M.	Progress in breeding for resistance to stem rust and leaf rust in wheat
	a. Spring Wheat: L. R. Waldron, G. S. Smith, R. G. Shands, D. W. Sunderman, A. B. Campbell, B. C. Jenkins, V. A. Dirks, J. W. Gibler, Alfredo Campos, J. A. Rupert
	b. Winter Wheat: C. O. Johnston, J. F. Schafer, L. P. Reitz, I. M. Atkins, A. M. Schlehuber, J. E. Andrews

c. Durum Wheat: R. M. Heermann, A. B. Masson

12:30-1:30 P.M. Lunch

W. M. Myers, General Chairman

1:30 P. M. Cooperative Panel: B. B. Bayles, Moderator

Panel Members: E. R. Ausemus, N. A. Borlaug, H. A. Rodenhiser, C. V. Lowther, L. P. Reitz, M. N. Levine

1. Cooperative program, its importance

2. New Material being increased
   (1) Winter wheat
   (2) Spring wheat
   (3) Durum

3. Sources of germ plasm and cooperative testing

8:00 P.M. Special Sections

1. Genetics, aneuploids and species building - Ruby Larson, Chairman

2. a. Chemical control of rusts-J. G. Dickson, Chairman, C. V. Lowther, J. E. Livingston, M. N. Levine

   b. Physiology of parasitism of rusts - G. A. Ledingham, Chairman

January 7 G. S. Smith, General Chairman

9:00 A.M. Reports from Special Sections

9:45 A.M. Other Objectives

1. Sawfly research - M. N. Grant
   C. W. Farstad
   H. McNeal
   R. M. Heermann

2. Spring frost resistance - L. H. Shebeski

3. Resistance to after-harvest sprouting - J. B. Harrington

Techniques, testing and design, C. H. Goulden

Preliminary seed processing, A. B. Masson

12:30-1:30 P.M. Lunch

Co-Chairmen-W. F. Hanna and B. B. Bayles

1:30 P.M. Future Plans

Monday Morning, January 5, 1953.

The General Chairman, Dr. K. W. Neatby, called the meeting to order at 9:20 A.M. He recalled the meeting of a committee of Canadian and American Scientists in 1924, to outline the objectives in a rust research program. Two of the members of that committee, Dr.E. C. Stakman and Dr. J. G. Dickson are taking an active part in the present conference. The 1924 committee decided to emphasize studies on epidemiology, physiologic specialization of the rusts, physiology of host-parasite relations, and breeding for resistance. The program launched in 1924 had a great influence, not only on rust research, but on the whole field of plant science in Western Canada. A large volume of scientific information has been built up in the interval. Although it is now realized that there is no permanent solution to the rust problem, the accumulated fund of knowledge places agricultural scientists in a much stronger position than ever before, to meet and solve new problems as they arise. Dr. Neatby expressed the pride of Canadians at being hosts to this, the first officially organized International Wheat Rust Conference.

It was suggested and agreed that there be two secretaries. Mr. Ruben Heermann was named by the United States group, and Dr. W. E. Sackston by the Canadian delegates.

The advisability of press representation was discussed. The chairman pointed out that, as the presence of reporters might impose some restraint on informal discussion in a working conference, and that as there would be much that the press representatives might not readily understand, it would be more satisfactory to have the secretaries supply information to the press. Dr. H. A. Rodenhiser and Dr. W. F. Hanna were named to assist the secretaries with press releases.

Dr. R. F. Peterson extended to those at the Conference an invitation on behalf of Dr. J. G. Taggart, Deputy Minister of Agriculture for Canada, to attend the banquet being tendered by the Government of Canada on Monday evening.

Speakers at the various sessions were requested to provide summaries of their discussions to the secretaries. All those present were asked to sign the attendance lists.

Dr. E. C. Stakman, Moderator of the "Panel on Stem Rust", then assumed charge for the morning program.

THE PRESENT STATUS OF THE STEM RUST PROBLEM

E. C. Stakman, Helen Hart, and D. M. Stewart.

The wheat stem rust situation changed abruptly and seriously in 1950 when race 15B became widespread and prevalent for the first time in North America, as far as is known. In 1950 race 15B comprised

27 percent of all uredial isolates of Puccinia graminis tritici identified at the Federal Rust Laboratory at St. Paul, Minnesota; in 1951 it comprised 40 percent; and in 1952 it comprised 58 percent. Not only has the prevalence increased, but the geographic distribution has been extended to most of the wheat-growing areas of North America, including those of Mexico and Canada. Moreover, 15B now has double insurance for survival, as it can overwinter in the uredial stage in southern United States and Mexico and through the intermediary of barberry in a fairly wide geographic zone in northern United States, extending from Pennsylvania and Virginia to the Mississippi River and beyond.

Prior to 1950 race 15B was found almost exclusively on or near barberry bushes, principally in the eastern United States, and had not become established where the uredial stage could overwinter. Its spectacular increase and spread in 1950 illustrates what may be expected in future, if susceptible barberry bushes remain to facilitate the persistence of old races and the production of new ones through sexual recombinations. Certain races have increased gradually and extended their range slowly in the past; others have spread rapidly, like 15B, without appreciable warning. The generalization seems justified that a race that becomes well established anywhere in North America is likely to become established everywhere, sooner or later, where there are susceptible varieties and favorable weather for rust development.

The history of races 15 and 15B before 1950 is summarized briefly by Stakman and Loegering in the "Physiologic races of Puccinia graminis in the United States in 1950" and need therefore not be repeated here, but there have been important subsequent developments that have not yet been recorded.

It was suspected, even in 1950, that 15B might comprise several biotypes, and the suspicion has been confirmed, as shown in the abstract by Stakman, Hart, Postigo, and Goto, which is included in these proceedings.

That there is confusion in some minds regarding the designation of biotypes and races is evident from questions that are raised frequently. This mental confusion is natural because the situation itself is naturally confused and nature keeps adding to the confusion. And yet, is it really more confused than the situation regarding Kenya wheats, with K58, K117A, K324, K338, K338 A.A.1.A.2, and K338 AC.2.E.2? In simplest terms there are unknown numbers of biotypes of stem rust that parasitize wheat, and new ones are either being produced continually or are obtruding themselves on our attention because of their scientific or practical importance. The only way now known of recognizing these biotypes is by their pathogenic effects. In the past one or more of these biotypes, presumably having certain genes in common, have been designated as races by means of the infection types produced on 12 so-called differential varieties of Triticum spp. that were selected as adequate representatives of several hundred varieties. But several hundred new varieties of Triticum and thousands

of hybrid lines have been produced. These may, and some do, constitute additional biologic indicators that show differences between biotypes that have looked identical on the wheat varieties previously available. Obviously, then, the adequacy of the tests by which biotypes are grouped into races is limited by the availability of testers and by facilities for making enough tests under enough conditions. The writers not only admit, but insist, that the system for identifying races must be revised. A system must be based on a situation; The situation has changed, and the system must therefore be changed also. But far more investigation is needed before it can be changed intelligently. In the meantime, the best that can be done is to learn as much as possible about important biotypes or groups of biotypes and classify and designate them as scientifically and conveniently as possible.

There already are indications that the race situation may change again, because races 11, 49, and 139 will find congenial soil in many of the new varieties, as shown in the abstract by Hayden, Smith and Stakman. The first two were prevalent prior to 1935, but were supplanted by races 56, 17, 38 and 19, which together comprised more than 90 percent of all uredial isolates in the United States from 1938 to 1949. The relative prevalence of all four has decreased as that of 15B increased; and in 1952 race 15B comprised almost 60 percent of the isolates, with races 56, 17, 38, and 19 combined comprising only 28 percent.

The changes and potential changes in the wheat stem rust situation due to shifting populations of rust races create complexities and uncertainties. But the complexity is increased by the fact that the reactions of some varieties to some biotypes of rust can vary greatly under different environments; consequently, relative resistance of some varieties may vary greatly with the season and with the region or locality in the same seasons. (See abstract by Hart and Stakman). Obviously, extensive physiologic and ecologic studies are needed.

The story of races 8 and 7 of oats stem rust is recorded in the physiologic race reports on Puccinia graminis avenae. The recent history of race 7 parallels almost exactly that of 15B of wheat stem rust, even to the finding of biotypes.

The future cannot be predicted except to predict that unpredictable changes are likely to occur. Without more extensive and precise knowledge regarding the genes for rust resistance in the cereal grains and grasses and regarding the genes for virulence in Puccinia graminis and the interactions between them under an adequate sample of environments, efforts to control stem rusts are necessarily somewhat empirical. Extensive research by many competent investigators with adequate physical facilities is essential. In the meantime, barberry eradication must be continued and should be intensified, the possible role of mutation in the production of rust races must be studied, and all available knowledge and skills should be combined to develop cereal

varieties that are as nearly universally rust resistant as possible and to devise practicable methods of chemical control if needed as sole or supplemental measures for reducing rust damage. (Cooperative investigations between the Minnesota Agricultural Experiment Station and the Bureau of Entomology and Plant Quarantine, United States Department of Agriculture).

Discussion:

R. G. Shands: Why did race 49 decline?

E. C. Stakman: We don't know why races change in prevalence when all the wheats grown are susceptible, but such changes do occur. Hope and H-44 are resistant to race 49. Only 3/10 of 1% of the isolates were race 49, but it was found in several states and in Mexico. Race 56 and other races were found on wild grasses.

T. Johnson: Race 49 was not found in Canada in 1952, but there were a few collections of it in 1951.

Major Strange: How long has rust been observed?

J. G. Harrar, N. E. Borlaug, J. A. Rupert: Rust has been found since early colonial times in Mexico. It was mentioned in records of 1517. The first record in Colombia was about 1700.

Glenn S. Smith: What is the reaction of the third biotype of 15B on Lee?

E. C. Stakman, Helen Hart: Type 3 pustules near the tip of the leaf, a more resistant type of reaction near the base of the leaf.

Question: Why is race 11 not more widespread?

E. C. Stakman: The prevalence of any given race is often fortuitous. It depends on wintering conditions, on the direction and velocity of winds, and temperatures and humidities at critical periods. Race 15B "escaped" from barberry areas to Mexico and the Southern United States, Telia were formed, and this race is now present on barberries in the north.

DISTRIBUTION OF RACES OF WHEAT STEM RUST IN CANADA IN 1951 AND 1952

T. Johnson

In 1951, a study was made of 178 isolates of wheat stem rust collected on wheat, barley, and wild barley (H. jubatum). These were identified as the following races (the number of isolates of each race in brackets): race 1 (2); race 2 (2); race 11 (1); race 15B (85); race 16 (1); race 17 (5); race 38 (5); race 48 (3); race 49 (1); race 56 (71); race 69 (1); race C.51-2 (1). Race 15B was found in Ontario, Manitoba, Saskatchewan, and Alberta, but the

major concentration was in Manitoba and Saskatchewan. Race 15B occurred also to a considerable extent in Alberta, but stem-rust infection in that province was caused chiefly by race 56.

In 1952, the stem rust survey comprised 307 isolates. The following races were isolated: race 2(4); race 11 (1); race 15B-1 (255); race 15B-2 (16); race 34 (1); race 38 (1); race 39 (1); race 48 (2); race 56 (25); race 139 (1). The two strains of race 15B, designated 15B-1 and 15B-2, were differentiated by means of the reaction of Golden Ball which is distinctly more susceptible to the last mentioned.

Race 15B appeared to have a wider distribution in 1952 than in the preceding year. It occurred in collections from all provinces except Prince Edward Island. Its greatest concentration was in Manitoba and Saskatchewan where it occurred almost to the exclusion of other races.

In both years, there was evidence for the presence in south-eastern British Columbia and southern Alberta of races 2 and 48 which do not appear to occur elsewhere in Canada.

Table 1.
Distribution by provinces of physiologic races of Puccinia graminis tritici collected on wheat, barley, and grasses in Canada in 1951 and 1952.

1951

Province	Physiologic races												Total no isolates
	1	2	11	15B	16	17	38	48	49	56	69	C.51-2	
Quebec	-	-	-	-	-	2	-	-	-	2	-	-	4
Ontario	-	-	-	4	-	-	1	-	-	2	-	-	7
Manitoba	-	-	-	26	-	-	1	-	-	6	-	-	33
Sask.	-	-	-	48	-	-	-	-	-	17	1	-	66
Alberta	-	1	-	7	-	3	3	1	1	38	-	1	55
B.C.	2	1	1	-	1	-	-	2	-	6	-	-	13
Total	2	2	1	85	1	5	5	3	1	71	1	1	178
Percentage	1.1	1.1	0.6	47.7	0.6	2.8	2.8	1.7	0.6	39.8	0.6	0.6	

1952

Province	2	11	15B-1*	15B-2**	34	38	39	48	56	139	Total No. Isolates
P.E.I.	-	-	-	-	-	1	-	-	1	-	2
N.S.	-	-	1	-	-	-	-	-	-	-	1
N.B.	-	-	2	-	-	-	-	-	-	-	2
Quebec	-	-	7	2	-	-	-	-	4	-	13
Ontario	-	1	21	1	-	-	-	-	1	-	24
Manitoba	-	-	119	9	-	-	1	-	1	-	130
Sask.	-	-	97	4	-	-	-	-	2	-	103
Alberta	-	-	6	-	1	-	-	-	10	1	18
B.C.	4	-	2	-	-	-	-	2	6	-	14
Total	4	1	255	16	1	1	1	2	25	1	307
Percentage	1.3	0.3	83.1	5.2	0.3	0.3	0.3	0.7	8.1	0.3	

* 15B-1 produces a 2- or 3- type of infection on Golden Ball
** 15B-2 produces a 4- type of infection on Golden Ball

Discussion:

E. C. Stakman: Race 7 of oat stem rust and 15B on wheat have shown parallel increase. Apparently both escaped from the eastern barberry areas at about the same time. There were unusual air currents in 1950, and the crop in the midwest was about five weeks later than usual. Race 48 was the commonest race from barberries in the northwestern United States. That seems to be related to its occurrence in British Columbia and Alberta.

J. A. Rupert: A "different" race 48 is the most prevalent one in Columbia.

BIOTYPES WITHIN RACES OF STEM RUST

E. C. Stakman, Helen Hart, R. Postigo, and S. Goto

It is becoming increasingly apparent that there are biotypes within certain races of wheat stem rust and of oats stem rust. It is, of course, impossible to be sure that an isolate is a single biotype even if cultures are started from single uredio-spores, because the possible importance of mutation in pathogenicity or other characters within a monosporous line of rusts is still unknown. That biotypes exist within races has been conclusively demonstrated, but several of them may behave alike on many varieties, and may be distinguishable from each other only on special varieties or under special environmental conditions. The degree of refinement attainable depends on the feasibility of using precise and laborious technique and the opportunity for testing many varieties under a wide range of environmental conditions. Relative purity of isolates is, however, obtained by isolating from single discrete pustules.

There are a considerable number of biotypes within race 15B. In the race survey made at the Federal Rust Laboratory in 1952, for example, three biotypes could be distinguished on Khapli emmer. An isolate from Iowa, and many others, consistently produced only flecks;

one from barberry in Virginia consistently produced type 1 or type 2 infection; and an isolate from Oklahoma produced type 1 to type 3-, depending on the part of the leaf infected, the highest infection type usually developing toward the tip. Studies were made of these three isolates at different temperatures and light intensities, and there always were clear-cut differences between them.

There are many more biotypes of 15B than those mentioned above. When 17 isolates, which had been selected because of preliminary indications that they might differ in pathogenicity, were grown under comparable conditions on the standard differential wheat varieties, quantitative differences in infection types produced by some isolates were apparent on some varieties. As an example, one isolate might consistently produce a type 4- on a given variety, and another one a type 4++ under the same conditions. Ninety-nine additonal varieties of wheat were tested and ten served as additional differentials, which made it possible to distinguish at least eight biotypes. Similarly, 11 varieties of barley made it possible to distinguish at least six additional biotypes. By means of these additional varieties of wheat and barley, therefore, 14 biotypes were distinguished among the 17 isolates.

Five isolates from Nebraska were studied intensively, and at least four were different in virulence on one or more varieties of wheat. As an example, at 85°F., Kenya 117A, a selection from Kenya 324 x Mentana, and (Renown x Marroqui) x (Aguilera x Kenya 324) were completely susceptible to an isolate from Prague but highly resistant to one from Lincoln.

Biotypes of 15B may be affected differently by temperature. Two that were studied produced the same infection types at 85°F. on all wheat and barley varieties tested, but at 65°F. Frontana wheat was resistant to one and susceptible to the other.

It is clear that there are biotypes within race 11 also, but this race has been found rather rarely in recent years and there has therefore not been opportunity to study many isolates.

There are biotypes within race 7 of oats stem rust also. In the survey of 1952 there were indications of differences on a selection of Clinton x Ukraine, but final conclusions were not drawn because the isolates were not always grown under identical conditions. Four isolates were therefore studied under comparable conditions, and there were minor but perceptible differences in infection types produced on some varieties at moderate temperature but not at high temperature. One of the isolates, however, was conspicuously different from the others, because it produced telia much more readily under all experimental conditions that were provided.

It is already known that a number of other races of wheat stem rust comprise biotypes and it is highly probably that most of them do. The chances of finding and identifying them depends partly on the adequacy of the samples that can be obtained in nature and partly

on the diversity of genetic combinations of susceptible groups of hosts. Prior to 1950 it never was possible to obtain an adequate sample of isolates of 15B in the United States because it occurred so rarely. Moreover, the increasing diversity of varieties and lines of wheat increased the number of potential differential varieties. That there are many biotypes is clear, but the problem of separating them is not always easy. What are now designated as biotypes may prove to comprise several biotypes, and some probably will eventually be elevated to the status of races. The present classification of races will necessarily be modified as new biotypes and races are produced and more host varieties become available for recognizing them.

Discussion:

C. O. Johnston, H. C. Young: It is commonly found in leaf rust inoculations that certain races of rust on some varieties produce susceptible type pustules at the tip of the leaf, ranging to 0 or 1 type pustules at the base of the leaf.

E. C. Stakman: The "place effect" on plants is not uncommon. Large pustules may occur near the nodes on resistant material in rust nurseries.

B. C. Jenkins: There may be biotypes of the host as well as of the rust.

E. C. Stakman: Kanred wheat was distinguished from some other similar varieties by its rust reaction, and strains within Kanred were distinguished by their reaction to certain races (17,21). At a critical temperature for the host variety, it may give a range of reactions that make it appear to be segregating genetically.

T. Johnson, Helen Hart: It is important to know the adult plant reaction of varieties to various isolates, because that is the important factor in crop production. It is almost impossible to test the adult plant reaction of large numbers of varieties to all isolates, so it is necessary to inoculate with composite samples of rust.

E. C. Stakman: From the practical standpoint of developing disease-resistant varieties, tests must be made with an adequate sample of biotypes of races. It takes a good deal of work to make sure an adequate sample is obtained. The tests must be made under controlled conditions. Greenhouse space and facilities must be sufficient to make tests on a large scale and at two, or preferably three, temperatures. The problem is complex, much more complex than was realized in 1924. We are used to thinking in academic terms; we must think in terms of large "workshops", with sufficient skilled help.

W. C. Broadfoot: At Lethbridge we are trying to develop plant-growth rooms rather than greenhouses, to get the same conditions the year around.

Major Strange: Are the facilities now available, adequate?

E. C. Stakman: If any investigator has 10% of the facilities or help he needs, he is lucky!

K. W. Neatby: Plant growth chambers cost about 10 times as much as greenhouse space.

Major Strange: It is important that those who are charged with voting funds should be made aware of the complexity of the problem, and of what is needed to do a proper job.

D. G. Fletcher: I do not think that the people of Canada and the United States have any conception of what is needed. The Congress of the United States does not understand fully. Scientists have been too much immersed in their own work. People have been told about accomplishments, not need.

E. C. Stakman: It is hard to appreciate the complexity of the problem until you have worked with it. Much basic genetical work has to be done. A new system for differentiating races has to be worked out. The differentials available were fairly adequate until 1950; they are still useful for historical purposes, but they are no longer adequate to determine the races attacking the new hybrid wheats.

THE RAPID INCREASE AND DISTRIBUTION OF STEM RUST RACE 49 FURTHER COMPLICATES THE PROGRAM OF DEVELOPING STEM RUST RESISTANT WHEATS FOR MEXICO.

Norman E. Borlaug(1), Ignacio Narvaez (2), and Teodoro Enciso(2)

When the wheat breeding program of the Oficina de Estudios Especiales(3) began in 1944 all the commercial Mexican bread wheats were susceptible to the prevalent races of stem rust, 17, 19, 38, 56, and 59. The improved varieties Supremo 211, Yaqui, Chapingo, Mayo, Kentana, Lerma, and Supremo 51, released by the office from 1946-51, were resistant to stem rust under field conditions until the summer of 1951 when race 15B appeared in Mexico. Of these varieties only Kentana, Lerma, and Supremo 51 are resistant to race 15B. Currently more than 50% of the entire wheat acreage of the republic is grown to these varieties. During June and July of 1951, race 49, (and related race 139), built up on late plantings of Kenya 324 in the state of Coahuila but there was no commercial damage so the outbreak was not reported to our office. However, by May 1952, 3,000 acres of Kenya 321 and 324 were killed by this race. By August, infection centers began to appear in many other areas on Lerma, Supremo 51, and on some of the Kentana reselections. Race 49 is particularly virulent on many of the Kenya wheats, Egypt Na 101, McMurachy and their derivatives. Hope, Timstein, Thatcher, Gabo, the Brazilian varieties and their derivatives are in general, resistant. Kenya 338 Ac.2.E.2 is one of the few Kenya wheats resistant to both race 15B and 49.

There is evidence that some lines of Kentana are moderately resistant

(1) Rockefeller Foundation.
(2) Mexican Dept. of Agriculture.
(3) Joint Dependency of Mexican Dept. of Agriculture and Rockefeller Foundation.

to race 49, however, this resistance is considered inadequate. Consequently several lines from 3 different crosses combining resistance to 15B, 49, and the common races are being increased for commercial release. The crosses are:

(1) II-2156 (Egypt Na101 x Timstein) x Mayo 48
(2) II-2254, II-2587, II-2589 Kentana x Yaqui 48
(3) II-1922 Kenya x (Mentana^2 x Supremo 211)

The rapid shifts in the populations of races of stem rust of wheat in the past few years indicates that there is a critical need for more adequate greenhouse testing of breeding materials against a larger number of individual races. Field testing alone is inadequate even though it is done on an interhemisphere basis. Better techniques most be developed for storing viable spores for long periods of time, if more extensive greenhouse testing is to be practical, since most programs are greatly limited in testing by a shortage of greenhouse space. Moreover, because of the magnitude of the problem, far more rapid progress can be made if cooperative arrangements can be made whereby different institutions will assume the responsibility of testing against a certain group of races and other institutions would test against a different group of races. The breeding materials which would be evaluated in such a procedure would of course include advanced generation lines from all of the North American programs. These data would supplement the field reactions of the materials which are now being evaluated in the Cooperative Inter-American Nurseries. The data which have been obtained from the Cooperative Inter-American Nurseries during the past three years have been very valuable and represents a very important advancement in wheat improvement methods. However, if additional greenhouse data can be obtained for a large number of races, faster and more reliable progress in the breeding programs will be assured.

Discussion:

G. S. Smith: Is there any evidence of genetic linkage between 15B resistance and susceptibility to 49?

N. E. Borlaug: We do not have enough data yet to be definite. We feel the linkage is fairly strong, but we can recover resistance to both races in crosses with H-44 and Hope, and the Kenya type of resistance.

Table 2 REACTION OF PARENTAL AND COMMERCIAL WHEAT VARIETIES TO STEM RUST AT CHAPINGO, MEXICO, DURING SUMMER SEASON 1945-52

	1945 %3/	R4/	1946 %	R	1947 %	R	1948 %	R	1949 %	R	1950 %	R	1951 1/ %	R	1952 2/ %	R
Mentana	100	S	100	S	100	S	100	S	100	S	100	S	100	S	100	S
Kenya 324	0		0		T	R	0		0		T	R	0		40	S
Marroqui	100	S	100	S	95	S	100	S	100	S	100	S	100	S	100	S
Newthatch	T	R	0	—	0	—	T	R	0	—	0		75	S	80	S
Supremo 211	0	—	T	R	0	—	T	R	5	R	T	R	100	S	100	S
"Yaqui 48" 5/	——	——	——	——	5	MR	5	R	10	MR	0	—	70	S	90	S
"Yaqui 50" 5/	——	——	——	——			0		T	R	0		30	S	50	S
"Mayo 48" 5/					10	MR	5	MR	10	MR	0		85	S	100	S
"Chapingo 48" 5/					5	MR	5	R	10	MR	T	R	80	S	100	S
Kentana 48 6/					0		0		0		0		0		15	MR
Kentana 51 6/							0		0		0		0		50	S
Lerma 50 6/									T	MR	0		5	MR	90	S
Timstein	T	R	0		5	MR	0		T	R	0		50	S	100	S
(Egypt Na 101 x Timstein) x Mayo 48 (II 2156)											0		T	R	0	—
Kentana x Yaqui 48 (II 2254)											0		0		0	

1/ First appearance of Race 15B
2/ " " " " 49

3/ Severity of Infection
4/ Reaction Type

a) R - Resistant
b) MR - Moderately Resistant
c) S - Susceptible

5/ Have Newthatch Resistance
6/ Have Kenya Resistance

THE PATHOGENICITY OF RACES 11, 49, AND 139 OF PUCCINIA GRAMINIS TRITICI TO KENYA WHEAT VARIETIES AND THEIR DERIVATIVES.

E.B.Hayden, D.H. Smith, and E.C. Stakman

Races 11, 49, and 139 can attack certain Kenya wheats and their derivatives under a wide range of environmental conditions. They cause heavy infection on Kenya 58, Kenya 117A, Lerma, and Kentana at 70° - 75° F. and at 80° - 85° F. Races 49 and 139 can develop well on Lerma and Kentana at a wider range of temperature than race 11. It is too early to generalize regarding the importance of these three races in the program of breeding against 15B because there has not yet been opportunity to study them extensively. According to the records and reports of the Federal Rust Laboratory at St.Paul, Minnesota, races 11 and 49 have been found only occasionally in the United States during the past decade, and race 139 never has been prevalent enough to be important.

Although not prevalent in 1952, races 49 and 139 attracted attention because they were isolates from field collections of certain Kenya wheats and certain crosses with Kenya parentage that were considered resistant to 15B under many conditions. It became evident very quickly, as a result of comparative tests, that both 49 and 139 exceeded the virulence of 15B on some Kenya and Kenya-type varieties, under at least some conditions. Similar information had already been obtained for race 11 as a result of comparative tests of several races in the greenhouse during the past two years.

Kenya 338 AA.1.A.2 and Kenya 338 AC.2.E.2. have been resistant to the isolates of races 11, 49, 139 and 15B with which they have been inoculated. Varieties deriving their resistance from Timstein, Thatcher, Frontana, and Vernal are resistant to races 11, 49, and 139, although they are at least moderately susceptible to some biotypes of race 15B, under some conditions.

Races 11, 49 and 139 constitute a potential threat to certain Kenya wheat varieties and their derivatives, although the seriousness of the threat cannot be known until more is learned about the homogeneity or heterogeneity of the races. Race 11 certainly comprises several biotypes, and the others may be heterogeneous in composition also. Any general statements or predictions, therefore, must be subject to possible modification as more information is obtained.

DIFFERENCES IN PATHOGENICITY AMONG ISOLATES OF RACE 11 OF PUCCINIA GRAMINIS TRITICI

D. H. Smith and E. B. Hayden

Six isolates of race 11 of *Puccinia graminis tritici*, obtained from widely separated geographic areas and identified at the Federal Rust Laboratory, St.Paul, Minnesota, were studied to determine whether there were differences in their pathogenicity. All isolates were similar on all the standard differential wheat varieties except that one of the isolates produced an unusually high infection type on Khapli emmer. The infection types produced by the majority of

the isolates on Khapli emmer ranged from 0; to 2. The unusually virulent isolate produced infection types ranging from 3 to 3^{+} + cn with a few 4-cn pustules on seedlings, whereas adult plants were moderately resistant to moderately susceptible. No two isolates were identical when compared on eleven additional wheat varieties being used as sources of stem rust resistance in current breeding programs. Therefore, race 11, as currently defined, comprises a number of biotypes. An isolate of race 32 produced similarly high infection types on Khapli emmer. Race 32 is similar to race 11 except that the standard differential durums have a mesothetic reaction rather than a susceptible reaction. The isolate of race 11 and the isolate of race 32 which were virulent on Khapli emmer were extremely sensitive to environmental conditions. In general, higher temperatures tended to increase sporulation. High temperature combined with full light favored development of host chlorosis and necrosis, with resulting limitation of rust sporulation. A number of breeding lines having resistance to race 15B and with Khapli in their parentage were tested at both moderate and high temperatures to the isolate of race 11 and the isolate of race 32 which were virulent on Khapli emmer, and to a composite of isolates of race 15B. In all cases the isolates of race 11 and of race 32 were less pathogenic than the composite of race 15B.

Discussion:

J. B. Harrington: Could it be the effect of temperature, rather than the rust, that causes the blotching at high temperature?

E. B. Hayden, Helen Hart: No, it is the effect of the rust.

Monday Afternoon, January 5.

Stem Rust Panel, continued:

UNITED STATES DEPARTMENT OF AGRICULTURE
AGRICULTURAL RESEARCH ADMINISTRATION
Bureau of Plant Industry, Soils, and Agricultural Engineering
Division of Cereal Crops and Diseases

(NOT FOR PUBLICATION WITHOUT PERMISSION)

REACTIONS OF WHEATS FROM THE WORLD COLLECTION TO 8 RACES OF STEM RUST IN THE SEEDLING AND ADULT STAGES AT 65-70° F. AND 80-85° F. IN THE GREENHOUSE AT BELTSVILLE, MD., 1951-52 1/

The reactions of 196 wheats from the world collection to 8 races of stem rust were obtained at Beltsville, Maryland during the winter of 1951-52. Readings were taken in the seedling and adult stages on plants incubated at temperatures of 65-70° F. and 80-85° F. with the following races: 11, 15B, 17, 19, 36, 38, 56, and 59. The seedling plants were inoculated in the two-leaf stage and the adult plants in late boot or early heading. Readings in the seedling stage were at the temperatures indicated, but in several cases the adult-plant reactions were obtained in late April or early May when it was impossible to hold the greenhouse temperature down to the 65-70° F. range. In fact, when several of the adult-plant readings were taken, temperatures were essentially the same for both the low and high ranges. Undoubtedly some of the adult-plant reactions listed in the table for the 65-70° F. range are more susceptible than they would have been had it been possible to maintain this temperature. Plants were grown at night and day temperatures of 50° F. and 60-65° F., respectively, except during the incubation periods.

1/ C. V. Lowther, Pathologist, Division of Cereal Crops and Diseases.

Plant Industry Station
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On the basis of the reactions obtained at the two stages of plant growth at the two temperatures the wheats could be placed in several categories. It is evident from the data presented in the following table that many of the wheats were resistant to all races under all conditions while others were susceptible in the seedling stage and resistant in the adult. Reactions to the 8 races were quite variable. More entries were susceptible to 15B than any other race, however, several were resistant to this race but susceptible to others.

Temperature greatly affected the reactions of many wheats, particularly the Kenyas. Some varied from highly resistant at the low temperature to completely susceptible at the high temperature. In some varieties this phenomenon occurred with all races, while in others it did not. For example, the reaction of Kenya 2G.6.A.9(L) (P. I. 92477) to each of the 8 races varied with temperature. In contrast, Kenya 3410.2.B.1 (P. I. 177183) was resistant under all conditions to race 17, but resistant to race 36 at the low range and susceptible at the high range in both stages of plant growth.

The "Entry No. 1952" listed in the following table refers to entries in the "Reaction of Wheats from World Collection to Stem Rust, 1952" distributed by Dr. B. B. Bayles.

VARIABILITY IN RUST REACTION

Helen Hart and E. C. Stakman

Stem rust reaction may be relatively stable as temperature varies from 65°F. to 85°F., as in Ceres wheat rusted with race 56 of wheat stem rust. Or the reaction may be changed completely within a 20-degree temperature range, as in certain Kenya wheats that are very resistant to races 56, 17, 38, and 15 at 65°F. and 72°F. but are susceptible to those races at 85°F. These temperatures affect adult plant reactions as well as seedling reactions, although the critical temperatures at which the reaction changes may vary for different host-race combinations. Three oats, Garry, Hajira x Joanette, and Victoria-Hajira-Banner, are resistant to the oat stem rust race 6 at 72°F, and are susceptible at 85°F.; but these oats are resistant to races 7 and 8 at 72°F. and at 85°F. and are susceptible only when the temperature reaches 90°F.

Light intensity of 1000 to 3000 foot candles favors rust sporulation but also favors chlorosis and necrosis of host cells in a resistant or moderately resistant host, whereas light intensity of 100 to 200 foot candles favors vegetative growth of rust mycelium but depresses rust sporulation and delays host cell necrosis. An extreme reduction in light to 20 foot candles may result in a very resistant reaction in a wheat variety that is susceptible to a rust race at the higher light intensities. Shortening day length from 8 or 14 hours to 4 hours may delay host cell necrosis, as does a low light intensity, but it reduces rust sporulation only slightly.

While the effects of temperature and light are most easily observed as they influence rust development, the environment also may affect the infection of a host. Occasional and slight reductions of infection types on susceptible hosts were observed when wheats inoculated with race 15B were kept in the moist chamber for 48 hours rather than 24 hours. Infection failures and difficulties in Kentana wheat have been studied histologically. Rust spores of 15B germinate and form appressoria over the stomata, but in many lesions, there are no evidence of rust hyphae within the leaf tissue. Nevertheless, host cells bordering the substomatal cavity are killed, presumably as a result of the rust appressorium outside the stoma. Similar lesions appear on the portion of the Kentana population that is very resistant to race 49, but they seldom occur on the portion that is susceptible to race 49.

SUMMARY REPORT ON THE REACTION TO STEM RUST AT SAINT CROIX, VIRGIN ISLANDS: MEXICO: AND BELTSVILLE, MARYLAND, IN 1951-52.

C. V. Lowther, Thomas Theis, and H. A. Rodenhiser

During the winter of 1951-52 a nursery of 4900 wheats was grown on the Island of St. Croix, V.I. The nursery was comprised of the varieties and selections included in the South American experiments, many foreign introductions, and hybrid lines from breeders in North America. Approximately 4800 of these wheats were tested in the seedling stage and 560 in the adult-plant stage, in the greenhouse at Beltsville,

Md. Inoculations in the greenhouse and at St. Croix were made with a composite of biotypes of race 15B which were originally isolated from collections of the prevalent types in commercial fields in the U. S. during 1950 and 1951. Field rust reactions were obtained on 1100 of these wheats at Obregon and Chapingo, Mexico.

There is adequate resistance from several sources to the races used in these tests. Of 35 introductions from Kenya, 9 were outstanding for resistance. Hybrids of some of these Kenyas with one of several commercial wheats were likewise highly resistant. Certain hybrids involving Egypt Na 101 and a few selections from crosses of Frontana with Newthatch were resistant.

Out of the approximately 4000 foreign plant introductions tested, only 31 entries had an appreciable degree of resistance in all tests. These are not all new sources of resistance, however, since some represent the Kenya and Egypt types previously reported. Fifteen of these introductions are from Portugal, five from Spain, two each from Africa, Argentina, Italy, and Abyssinia, and one each from Colombia, France and Russia.

There appear to be several sources of resistance in the durum wheats. On the basis of these and previous tests, the following are most promising: Beladi 116 from Egypt (P.I. 153777), Tremez Molle, Tremez Preto, and Tremez Rijo from Portugal and Chapinge from Canada. Trigo Glutinoso (P.I. 174699) was resistant in the present tests, but had 25 percent infection in Peru.

Copies of this complete report may be secured from the U. S. Department of Agriculture, Bureau of Plant Industry, Division of Cereal Crops and Diseases, Beltsville, Md.

Dr. Rodenhiser also added the information that the oat varieties Santa Fe, Landhafer, and Trispernia, used as sources of resistance to crown rust in North America, are all susceptible in Argentina and Brazil. A cross of Clinton x Ukraine is resistant.

THE EFFECT OF TEMPERATURE UPON WHEAT SEEDLING REACTION TO 15B OF PUCCINIA GRAMINIS TRITICI

J. G. Dickson

The seedling reaction to race 15B, highly virulent isolate from Madison. Wisconsin, was determined on a number of new wheat selections at 16° and 24°C., under good light, and day length between 9 and 10 hours. Grouped on the basis of response to temperature; 26 resistant at low temperature susceptible at high, 2 susceptible at low temperature resistant at high, and 26 showed the same response at both temperatures. Kenya derivatives showed a significant trend towards susceptibility at high temperatures although there were a number of exceptions.

EFFECT OF ENVIRONMENT ON VARIETAL REACTIONS TO STEM RUST OF WHEAT

G. J. Green

Tests carried out under controlled greenhouse conditions in 1950-51, which have been previously reported in mimeographed circulars, show clearly some effects of different temperatures on stem rust reactions.

It was found that the reactions of some wheat varieties to particular races of stem rust were the same at temperatures of 65°F and 80°F. The reactions of certain other varieties were distinctly modified at the higher temperature. In some cases only a slight increase in susceptibility was observed, while other varieties showed a reversal of reaction from very resistant at the lower temperature to susceptible at the higher temperature. In these tests any change in reaction was always to greater susceptibility at the higher temperature, but an increased susceptibility to a particular race did not always mean an increased level of susceptiblity to all races.

Varieties resistant at the lower temperature in the greenhouse have usually shown good resistance in the field at Winnipeg. In 1951, in a special 15B nursery, the resistance of several of these varieties broke down. The variation in infection types and the occurrence of a period of abnormally hot weather fum July 23 to August 2 indicated that this breakdown of resistance was a result of abnormal environmental conditions which prevailed while the infections were developing.

Varieties of wheat whose resistance breaks down at high temperatures are of little use in areas where temperatures usually exceed the critical limit during the growing season, but they may be of considerable value in cooler areas. For example, the resistance of McMurachy breaks down at high temperatures, but this variety and its derivatives have generally shown excellent resistance in the field at Winnipeg.

This example of the effect of an environmental factor on reaction to stem rust reemphasizes the necessity of carrying out varietal tests under a range of environmental conditions.

Discussion:

E. C. Stakman: We usually think resistance increases as plants get older, but in some cases it decreases. Reaction can be shifted in either direction by changes in temperature or age of plants. We need to know the fundamental physiologic relationships involved.

T. Johnson: The breakdown in rust resistance as a result of high temperature may be less important in Canada than in the United States. That is why C. T. 186 may be more valuable here in Canada than in the U. S.

N. E. Borlaug: Response of the Kenya varieties is complicated. They are susceptible to 15B at high temperatures in the greenhouse, but when grown in the field they did not rust. It is important to correlate responses at different temperatures with the field reaction.

E. C. Stakman: We do not know what environmental sequences occur in nature.

BIOTYPES IN RACE 15B

T. Johnson

A search for biotypes in race 15B has shown that at least two strains exist that may be distinguished from each other by the infection types produced on the durum wheat Golden Ball. One of these produces a 2+ or 3- infection, the other a 4 type. The first of these strains, provisionally designated 15B-1, is of common occurrence; the second, 15B-2, is rather rare. Certain cultures, not readily identifiable as one or the other, may represent an intermediate type. The second, more virulent, strain was first noticed in a single collection in 1951, but was found present in 16 collections in 1952.

There is some evidence for the existence of strains in race 15B that differ in degree of parasitic vigor rather than in host specialization. One such, found in 1950, required about 5 days beyond the normal incubation period for the formation of uredia. Another, collected in 1951, produced slightly weaker infection types on nearly all varieties tested than did other cultures.

Table 5. Seedling reactions of wheat varieties to 22 cultures of race 15B.

Varieties	3 cultures collected in 1950 and 18 collected in 1951	Culture #32-51
COMMON WHEAT		) Same reactions
Kenya C. 6042	R	) Having selected
" C. 10857	VR	) out a Golden Ball
" C.D. 4132	R	) heavy strain two
K.58 F. (L.)1	VR	) cultures of it
K. 117A	R	) were compared with
K.60B.12.B.16 (L.)	MR	) two cultures of
K.UX.9.M.1.A.9.D.2	MR	) the usual type of
K.178.Q.8	R	) race 15B on about
K.192.Q.2.A.(L.)	R	) 130 selected wheat
K.291.J.1.1.1.	VR	) varieties (mostly
K.294.M.7.C.1.C.	R	) varieties shown
K.294.M.7.C.6.A.	R	) previously to be
K.294.H.2.A.1.	R	) resistant or mod-
K.318.A.J.4.A.1	R	) erately resistant
K.321.B.T.1.B.1	R	) to race 15B in
K.337.V.1.B.1.	VR	) the field). No
K.337.V.3.A.1	VR	) significant differ-
K.338.A.A.1.A.2	R	) ences in virulence
K.338.A.C.2.E.3	R	) were observed

Table 5-continued

Varieties	3 cultures collected in 1950 and 18 collected in 1951	Culture #32-51
K.340.Y.6.B.3	R	) except on the durum
K.344. AD.1.D.1.	R	) wheat Semental de
K.344. AD.1.D.3	R	) Sevilla which re-
K.344. AD.3.A.2	R	) acted like Golden
K.350. AE.4.A.1	VR	) Ball.
K.350. C.2.B.2	VR	)
K.360.H.	R	)
N.A. 95 Egypt	MR	)
DURUM WHEAT		
R.L. 1714 (Golden Ball x R.L. 1317)	MS	S
Balaturka, R. L. 1412	MS	S
Africanum (I-37-5)	S	S
R.L. 1731 (Chapinge x R.L.1317)	MS	MS
Gaza	MR	MS
Iumillo	MS	MS
Golden Ball	MS	S
Chapinge	MS	MS

VR = 0 and 0; - R = 1 - MR=2 - MS = 3= to 3 and X - S = 3+ to 4

VARIETAL TESTS WITH STEM RUST RACES COLLECTED IN 1951 AND 1952
T. Johnson

Eleven stem-rust races collected in Canada in 1951 were used for infection tests to determine their pathogenicity to wheat varieties in the seedling stage. In addition to race 15B the following races were used in the tests: 2, 9, 11, 17, 29, 48, 49, 56, 69, and C-51-2. Of the common wheat varieties tested, the following showed high resistance to all the races: McMurachy, Kenya R.L. 1373, K.58.F(L)1, K.337.V.3.A.1, K.338.A.C.2.E.3, Kenya C.10857, R.L. 2632 (2265 x Redman^3), R.L. 2651 (That. x (2265 x Redman^2)). The two varieties K.117A and K.338A.A.1.A.2 were resistant to some races and moderately resistant to others.

The strain of race 15B virulent to Golden Ball (designated 15B-2) was compared with other cultures of race 15B for pathogenicity to many common wheat varieties and a number of durum varieties. There was no noticeable difference in the virulence of these strains to varieties of common wheat, but strain 15B-2 was distinctly more virulent on both seedling and adult plants of Golden Ball and several hybrids derived from crosses with Golden Ball.

A group of wheat varieties is at present undergoing tests against stem-rust races collected in Canada in 1952.

Table 6. Seedling reactions of wheat and barley varieties to 11 races of wheat stem rust collected in 1951

	Races										
	Race 2 #52-51	Race 9 S.C. 12	Race 11 #55-51	Race 17a 193-51	Race 29 #170-51	Race 48 #56-51	Race 49 #166-51	Race 56 #51-51	Race 69 #42-51	Race C-51-2 #198-51	Race 15B #190-51
Common Wheat											
Thatcher	VR	VR	MS	VR	VR	VR	VR	R	VR	VR	S
Redman	R	S	S	MS	S	MS	R	R	R	S	S
McMurachy	VR	VR	VR	VR	VR	VR	VR	VR	VR	VR	R
Kenya, R.L.1373	VR	VR	VR	VR	VR	VR	VR	VR	VR	VR	R
K.58 F.(L)I	VR	VR	VR	VR	VR	VR	VR	VR	VR	VR	VR
K.117A	R	MR	MR	MR	MR	R	MR	R	R	MR	MR
K.294 M.7.C.I.C.	VR	MR	MS	R	MS	MR	MR	MR	R	R	R
K.337 V.3.A.1	VR	VR	VR	VR	VR	VR	VR	VR	VR	VR	VR
K.338 A.A.1.A.2	R	MR	MR	R	MR	R	R	MR	R	R	R
K.338 A.C.2.E.3	R	R	R	R	R	R	VR	R	VR	VR	R
K.340 Y.6.B.3	S	MS	S	S	MS	MS	S	S	MR	S	MR
K.344 A.D.3.A.2	VR	VR	S	VR	VR	VR	VR	MS	VR	R	R
Kenya, C.10857	VR	VR	VR	VR	VR	VR	VR	VR	VR	VR	VR
Gabo	VR	R	VR	R	VR	R	VR	VR	R	VR	MS
Yalta	R	R	VR	R	R	R	R	R	R	VR	S
Charter	VR	R	VR	R	R	R	VR	VR	R	VR	MS
Lendee	VR	R	VR	R	R	R	VR	VR	R	VR	S
Bencubbin	VR	S	S	R	S	S	MS	S	S	S	S
Celebration	VR	S	VR	R	S	VR	R	VR	VR	VR	S
R.L.2605 (R.L.2265 x Redman^3)	VR	S	S	MR	S	S	VR	VR	VR	S	S
R.L.2619("	S	S	S	S	S	S	S	S	Seg.	S	S
R.L.2624("	VR	VR	Seg.	Seg.	Seg.	MS	Seg.	VR	VR	Seg.	Seg.
R.L.2632("	VR	VR	VR	VR	VR	VR	VR	VR	VR	VR	R
R.L.2662("	VR	Seg.	Seg.	Seg.	Seg.	MS	Seg.	Seg.	VR	Seg.	Seg.
R.L.2651(That.x 2265 Redman^2)	VR	VR	VR	VR	VR	VR	VR	VR	VR	VR	R
Lee	R	R	R	R	R	R	R	R	R	R	S
Durum wheat											
Carleton	VR	MR-MS	VR	VR	VR	VR	VR	VR	MR	VR	S
Stewart	VR	MS	VR	VR	VR	VR	VR	VR	R	VR	S
Iumillo	VR	VR	VR	VR	VR	VR	VR-MR	VR	VR	VR	MS
Agili Blanc 168.10112	R	R	MS	R	MS-S	R	VR	MR	R	VR	MS
Yaroslav Emmer	VR	MS	R	MR	R	S	VR	VR	R	MS	S
T.timopheevi	VR	VR	VR	VR	VR	R	VR	VR	VR	VR	MS

Table 6-continued

	Races										
	Race 2 #52-51	Race 9 S. C. 12	Race 11 #55-51	Race 17a 193-51	Race 29 #170-51	Race 48 #56-51	Race 49 #166-51	Race 56 #51-51	Race 69 #42-51	Race C-51-2 #198-51	Race 15B #190-51
Barley											
Moore	MS	MS	S	S	MS	MS	S	MS	S	MS	MS
Montcalm	MS	MS	S	S	MS	S	S	MS	S	S	MS
Chevron	MS	R	MS	MS	R	VR	MS	R	MR	MS	MR
Vantage	MR	VR	MR	MR	R	R	MR	R	MR	MR	MR

VR = 0 and 0;
R = 1
MR = 2

MS = 3- to 3 and x
S = 3+ to 4

Discussion:

E. C. Stakman: It is apparent that there is an indefinite number of biotypes of wheat stem rust, and that new ones are continually appearing. Barberry eradication should be extended to cut down on this source of new rust races. The role of mutation in producing new races and biotypes is not well enough known. Biotypes are often hard to find. A new system of identifying races is needed. There is a high degree of specificity between rust biotypes and lines of wheat, and a great deal of variability in reactions induced by changes in environment. The sequence of environmental factors may be important.

The rust problem is a hemispheric one. We dare not bring races from South America to test under field conditions, but we must know their effects on our wheat varieties, because South American or similar races may someday be introduced by winds across the equator, or may be produced naturally in North America.

In order to solve the practical problems of controlling rust damage, the work must be done on a much larger scale than ever before. More facilities and more trained man power are needed.

We also need much more basic information. When we know "why" things happen, we can predict what is likely to happen.

K. W. Neatby: Is anybody planning work on mutation rates in stem rust? Is the instability of the rusts as great as that of the smuts?

E. C. Stakman: We do not know enough about mutation in the rusts. It must be studied. It would be necessary to obtain rust lines that are homozygous with reference to a given set of differentials, and establish the "normal" mutation rate, then experiment with mutagenic materials. Most of the mutants would be recessive and hard to determine.

Differences between "biotypes" of rust races may be very small, and continuous, rather than distinct. The term "biotype" is useful in discussing rusts, but it may not mean much.

Dr. Neatby thanked Dr. Stakman and stated that the panel on stem rust alone had already justified the conference.

Dr. H. A. Rodenhiser, General Chairman for the remainder of the afternoon, then called on Dr. T. Johnson, Moderator, to take charge of the "Panel on Leaf Rust".

PANEL ON LEAF RUST

T. Johnson: In 1937 and 1938 we thought we had the leaf rust situation under control, when Hope derivatives were released. They carried only light infections. In 1944, 1945, and 1946 these varieties began to rust so heavily that they could be considered susceptible, because of the build-up of biotypes of leaf rust races 5 and 15. Almost any collection of leaf rust in Western Canada is now virulent to Hope and H-44 derivatives. The situation is different in eastern Canada and west of the Rockies.

The older differential hosts are historically important and help to show if races in different areas are the same, but they are no longer dependable for distinguishing races that are currently important, and leaf rust investigators everywhere have been changing them. As soon as a culture of a rust race is found that attacks a previously resistant host, that host becomes a differential variety. Workers in the different areas should try to carry on their work in such a way that it is intelligible to groups elsewhere.

DISTRIBUTION OF PHYSIOLOGIC RACES OF LEAF RUST IN CANADA, 1951 and 1952

A. M. Brown

The rust surveys of the past few years indicate that the races of leaf rust prevalent in Canada may be segregated on a geographical basis. In Ontario and the Maritime Provinces race 58 is most commonly present. To this race the varieties Hope, H-44-24 and their derivatives are resistant in the seedling stage, whereas Golden Ball, Thatcher, Rescue, Jones Fife, Carleton, Gaza, Stewart and McMurachy are fully or moderately susceptible. In the Prairie Provinces the most common races are 5a and 15a. To these races the varieties Hope, H-44-24 and their derivatives are susceptible but Golden Ball, Carleton, Gaza, and Stewart are resistant. From southeastern British Columbia and southern Alberta, races 1a and 11 are usually isolated. To the former race Hope, H-44-24, Renown, Redman, Pilot, Mida, Cadet, and Regent are susceptible but to the latter race these varieties are resistant with the exception of Regent, which is susceptible to it. To all of these races Exchange and Frontana are resistant. Lee is moderately susceptible to race 11 in the seedling stage. Since cultures of the same race of leaf rust may not be identical, it seems advisable that varieties should be tested to more than one culture of a race before deciding whether they are resistant or not.

Table 7. Distribution by provinces of physiologic races of Puccinia triticina isolated in Canada in 1951 and 1952

1951

Prov.	Physiologic races 1	1a	5	5a	9	11	15	15a	38	58	93	126	126a	128a	140	140a	Total
P.E.I.	-	-	-	-1	-	-	-	-	-	2	-	-	-	-	-	-	3
N.S.	4	-	-	-	-	-	-	2	-	6	-	-	-	-	-	-	12
N.B.	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	2
Que.	1	-	-	-	-	-	-	2	-	14	-	-	4	-	-	-	21
Ont.	-	-	1	4	3	-	3	3	2	43	3	2	3	-	-	1	68
Man.	1	2	-	46	-	1	1	41	-	1	-	5	14	-	1	-	113
Sask.	-	-	-	18	-	-	-	19	-	-	-	4	4	-	-	-	45
Alta.	23	13	-	10	-	13	1	14	-	-	-	5	3	-	-	-	82
B.C.	6	9	-	-	-	4	-	1	-	1	-	-	3	2	-	-	26
Total	35	24	1	81	3	18	5	82	2	67	3	16	31	2	1	1	372
%	9.4	6.5	0.3	21.8	C.8	4.8	1.3	22.0	0.5	18.0	C.8	4.3	8.3	0.5	0.3	0.3	

1952 (incomplete data)

	Physiologic races 1	1a	3	5	5a	9	11	15	15a	38	58	93	126	126a	128a	141	Total
P.E.I.	-	-	-	-	-	-	-	-	1	-	1	1	-	-	-	-	3
N.S.	-	-	1	-	-	-	-	2	1	-	8	-	1	1	-	-	14
N.B.	-	-	-	1	2	-	-	-	1	-	5	-	-	-	-	-	9
Que.	-	1	1	-	2	-	1	2	3	1	20	-	1	-	-	-	32
Ont.	-	-	-	-	2	-	2	2	4	-	27	-	7	3	-	-	47
Man.	-	-	-	1	27	-	-	-	39	-	1	-	4	2	-	1	75
Sask.	-	-	-	-	18	-	-	-	16	-	2	-	4	7	-	-	47
Alta.	-	-	-	1	5	2	2	1	5	-	1	-	-	-	-	-	17
B.C.	1	12	1	-	2	1	3	1	1	-	-	-	2	-	2	-	26
Total	1	13	3	3	58	3	8	8	71	1	65	1	19	13	2	1	270
%	0.4	4.8	1.1	1.1	21.4	1.1	3.0	3.0	26.3	0.4	24.1	0.4	7.0	4.8	0.7	C.4	

Note: The letter a as in 1a, 5a, etc. signifies that the race is virulent to Hope, H-44 and their derivatives.

Discussion:

<u>T. Johnson:</u> Races are not the same in southern Alberta and northern Alberta. Leaf rust apparently moves across the mountains, because races are the same in southern Alberta and British Columbia. Races in northern Alberta are similar to those in Manitoba.

PREVALENCE AND DISTRIBUTION OF PHYSIOLOGIC RACES OF THE LEAF RUST OF WHEAT IN THE HARD RED WINTER WHEAT GROWING AREA OF THE UNITED STATES

C. O. Johnston

There have been significant changes in the prevalence of physiologic races of leaf rust in the hard red winter wheat area of Texas, Oklahoma, Kansas, Colorado, and Nebraska in the past five years. The complexes of races represented by races 9 and 58 decreased while that of race 5 increased tremendously. This is well-illustrated in the following table showing the prevalence of 8 important race complexes during two consecutive 5-year periods:

Years	Percent of total isolates represented by physiologic race complex								Total Number	
	5, 52	9, 10, 13, 19, 20, 31	15, 2	21	28	58, 44	77, 42, 122	105, 126	Isolates	Collections
1942-46	8.0	37.9	8.4	0	0.6	11.6	0.1	23.2	802	315
1947-51	33.2	26.4	9.6	1.8	0.4	2.8	0.6	22.5	1526	435

The large increase in the prevalence of race 5 occurred rather abruptly in Kansas in 1946 and seems to be correlated with a large and rapid increase in the acreage of Pawnee wheat. For example, race 5 comprised only 1.6 percent of all isolates from Kansas leaf rust collections in 1945 but comprised 17.3 percent of the total isolates in 1946. It increased to 37.4 percent in 1951 when Pawnee comprised 38.7 percent of the Kansas wheat acreage. Other races to which Pawnee is susceptible (all but the race 9 group shown above) apparently have been unable to compete successfully with race 5 and have mostly increased only slightly or have decreased.

A somewhat similar situation has developed with regard to the race 105,126 complex in Oklahoma. This race group comprised 18.6 percent of all isolates in collections from that state during the period 1942-46 and increased to 35.4 percent for 1947-51. This may be correlated with an increase in the acreage of the variety Westar in Oklahoma. H. C. Young and D. F. Wadsworth, in experiments at Stillwater, have found that Westar is susceptible to at least one biotype of race 105.

Although the race determinations from 1952 collections are incomplete, they indicate that other changes are under way in various

parts of the United States. The very virulent races 35 and 122 appear to be increasing, although not to an alarming extent as yet. To date, race 35 has been isolated from collections from Georgia, Texas, Iowa, Minnesota, and Wisconsin and race 122 from collections from Virginia, Georgia, Wisconsin, Kansas, and California. On the other hand the less virulent race 11, which usually is abundant only in Pacific Coast states, has been isolated from collections from New York, Virginia, Texas, Idaho, and California. Race 11 is the dominant race in Mexico. Race 93 still appears to be abundant only in southeastern United States. Race 58 is a dominant race in the Ohio Valley and throughout the eastern and southern states from New York to Georgia.

Evidence is accumulating at Manhattan that environmental conditions have a marked effect on physiologic race determinations. For example, cultures that appeared to be race 52 during the fall and early winter gave typical reactions for race 5 in the spring when days were longer, light more intense, and temperatures higher. In the same manner cultures that were typical race 2 in the fall proved to be race 15 in the spring, while cultures that at first appeared to be race 105 later proved to be race 126. These fluctuations are brought about by the reactions of the differential varieties Carina, Brevit, and Hussar which are known to vary under varying conditions of temperature and light. Thus there is increasing evidence that some of the described physiologic races are merely ecotypes. There also is evidence that definite biotypes of some races, such as 5, 9, 15, and 105, exist. In most cases the differences are only slight, but constant, but in the case of 105, at least two rather widely different biotypes occur.

Discussion:

J. B. Harrington: Are changes in race identification at different times due to differences in the amount of artificial light?

C. O. Johnston: We do not use artificial light. It is not practical to differentiate between two races of this type because they induce the same reactions.

H. C. Young: It is not just light, but light and temperature working together that may influence the switch from one reaction type to another.

PREVALENCE, DISTRIBUTION, AND PATHOGENICITY OF WHEAT LEAF RUST RACES IN THE UPPER MIDWEST REGION OF THE UNITED STATES.

M. N. Levine

While there was generally but little change in the composition of the physiologic races of wheat leaf rust isolated from the collections obtained in the Upper Midwest region during the past three years, there appeared to be some sharp deviation

in the pathogenicity of a few isolates bearing same numerical designations due to their parasitic behavior on the traditional differential varieties. Thus, for example, until the year 1949 the variety Lee was consistently highly resistant in the seedling stage to 36 of the 48 physiologic races ever isolated from Upper Midwest collections and only moderately susceptible to one of these, namely race 12. However, in 1949 and again in 1950 some isolates of race 11, pathogenically indistinguishable on the standard differentials, produced quite normal infection on Lee seedlings. Also, from among the 1950 collections biotypes of race 5, 6, 28, and 126 were isolated which attacked Lee rather severely. Again, in 1951, half a dozen isolates of race 5 and one of race 16 produced infection types "3" and "4" on Lee in the seedling stage. On the other hand, Lee seedlings were extremely resistant to every culture of the six races isolated from the 1952 collections, among which race 5 for one was fairly common.

Most prevalent in the Upper Midwest, during the quarter-century 1925-49, were the following five races in their order of frequency, namely: race 9--10.7%, race 128--10.4%, race 126--8.8%, race 5--8.7%, and race 15--6.8%. Races 5 and 9 have been present in this region since the beginning of the second quarter of this century; race 15 was first found here in the 1930's; races 126 and 128 made their first appearance in the hard red spring wheat area in the 1940's. The last named race has not been isolated even once during the past five years, whereas the other four races are still present in varying proportions; two of them, races 15 and 5, have even forged themselves to the head of the line, replacing races 9 and 128, respectively. The five races that dominated the scene in the Upper Midwest during the three-year period 1950-52, arranged themselves in the following order: race 15--17.5%, race 5--15.8%, race 52--15.2%, race 2--9.5% and race 126--5.7%. Races 15 and 2 are very closely related; and so are races 5 and 52. Within each pair, the races differ from each other only in their relative virulence on the differential variety Hussar. This differential is resistant to race 15 and 5, but susceptible to races 2 and 52. These pathogenic differences not infrequently are concealed if not entirely obliterated by sharp changes in temperature and/or illumination.

Each of the seven most prevalent physiologic races discussed in the foregoing paragraph, i.e. races 2, 5, 9, 15, 52, 126, and 128, have at one time or another been found in each of the four states constituting the Upper Midwest area, namely: Minnesota, Montana, North Dakota, and South Dakota. Nor were the biotypes mentioned in the first paragraph confined to any particular state. Neither was Lee the only variety capable of differentiating any of the referred to biotypes and several others, such as those discussed in the Plant Disease Reporter, Supplement 199, dated March 30, 1951.

SOURCES OF RESISTANCE TO LEAF RUST OF WHEAT

M. N. Levine

As shown in Supplement 199 of the Plant Disease Reporter, only 13 of the 113 varieties and selections of different wheats, tested in the seedling stage at St.Paul, Minn., were resistant to each of the physiologic races of leaf rust used in the study. These resistant wheats and the number of rust races they were tested with in each case are as follows: Apulia x Progreso, C.I. 12587--22 races; Cappelli, C.I. 12452--29 races; Exchange, C.I. 12635--32 races; Gabo, C.I. 12795--21 races; Klein Titan, C.I. 12615--21 races; La Prevision 25, C.I. 12596--32 races; McMurachy-Exchange x Redman, C.I. 12832--24 races; McMurachy-Exchange x Redman, C.I. 12833--17 races; Premier x Bobin^2-Gaza, C.I. 12821--32 races; Timopheevi, C.I. 11802--26 races; Timstein x Newthatch, C.I. 12634--24 races; Wabash x American Banner, C.I. 12878--16 races; and Warden x Purkof, C.I. 12879--16 races. All of the above are spring wheats; except the last two, which are winter wheats; and Cappelli, which is a durum variety. Each and all of these varieties may conceivably be susceptible to races yet untried or to biotypes of any of the races used in the tests already made. Only further and continuous testing of these and other lines will demonstrate their resistance under all circumstances.

While the above summary is a recapitulation of recently published data, the following discussion covers results of an as yet unreported study. This study deals with a total of 133 selections of 31 different wheat hybrids; of the latter, one was of Canadian origin, eight of Mexican origin, and the 22 others of American origin. Only one of the 133 selections was tested with as few as 6 races; 16 lines were tested with as many as 26 races each; the bulk of the selections averaged more than a dozen races apiece. Even a smaller proportion of the lines involved in this study was resistant to every race used than was the case with the material analyzed in the first paragraph: 14 out of 133 in this instance instead of the 13 out of 113 in the other. The resistant hybrid selections and the number of races each was tested with are as follows: Mida x Timstein, Minn. II-42-71 and 72--14 races each; R.L. 2265 x Redman--20 races; Timstein x Newthatch, C.I. 12739, C.I. 12740, and Minn. II-42-28, 32, 35, 36, 37, 40, 41, 42 and 60--14 races each. It will be noted that the first of the three crosses just listed was composed of two generally resistant selections; while the last one embraced as many as ten such selections. It is yet to be determined to how many other races these selections would prove resistant or whether they would retain their resistance to any biotypes of the races used, should such ever turn up.

Isolated instances of a "breakdown" in the resistance of some promising varieties is already on record. Thus, in the cooperative uniform cereal rust observation nurseries we find that the variety Exchange scored a coefficient of infection of 40% at Moscow, Idaho, in 1948; the variety Lee ran up an infection coefficient of 27% at Urbana, Illinois, in 1951. These are isolated cases, of course, but sometimes they are indices of

future happenings.

Discussion:

T. Johnson: I am interested in the reaction of Lee wheat because it has been distributed in Western Canada and we need to know its resistance to leaf rust. Race 11 is found occasionally in eastern Canada, but most collections of 11 do not attack Lee.

M. N. Levine: It usually takes about five years for a variety to become generally susceptible, so Lee may have five years still to go.

C. O. Johnston: New races, such as 5, seem to come in, and blanket an area vacated by older races as new, resistant varieties of wheat are introduced.

M. N. Levine: The mutation rate may be higher in leaf rust than in stem rust.

CURRENT STATUS OF WHEAT LEAF RUST IN INDIANA
Ralph M. Caldwell and John F. Schafer

The distribution of races of leaf rust is not uniform through Indiana. During the last decade in contrast to the two previous decades, there has not been extensive overwintering of leaf rust in Indiana with the exception of the snow belt at the northern edge of the state. In this area where there is overwintering, races which attack Vigo wheat have been prevalent, particularly race 76 or 58. Where infection is dependent primarily on windblown inoculum, races attacking Vigo have been less predominant, and other races, particularly 5 and 30 or 104 are more common. It appears that the increased production of soybeans and resulting late planting of wheat following soybeans, may have contributed to the recent lack of overwintering of leaf rust in Indiana. Because of the resulting race situation, Vigo wheat has made a great contribution in its leaf rust resistance in spite of the qualms about the effectiveness of its resistance at the time of its release in 1946. Presumably this has been possible only because of the absence of the Vigo type of resistance in the inoculum source area.

At the present time 14 auxiliary varieties are being used in the race testing program in addition to the 8 standard differential varieties. Among the races identified in the past three years, race 76 or 58 has predominated, race 5 has been second in importance, and there has been considerable race 30 or 104 or closely related races. Races 15 and 65 have dropped from their earlier important roles. However, race 15 may be occasionally missed, due to the sampling methods. It is suspected that race 5 may have replaced 15 in the rust population of this area on the basis of the historical records of occurrence and the fact that the two are similar except for their reactions on Malakof. Races to which Hussar is susceptible, such as 80,

and those to which Mediterranean is resistant, such as 9, both frequently collected in the past, are not now common.

In the past three seasons two new biotypes of leaf rust have been collected in Indiana which are threats to the resistance breeding program being conducted. The first of these which keys most closely to race 35 has been collected only once in Indiana, in 1950. It produces a 4 type seedling reaction on selections of 3369-61-1 (Wabash x American Banner) which had previously shown seedling resistance to all races tested at Lafayette, Indiana; Manhattan, Kansas; St. Paul, Minnesota; and Winnipeg, Manitoba. It further differentiated two groups of these selections in the mature plant stage and gave a 50 percent reading late in the season on the better group in 1951, although only a trace in 1952. Another collection of race 35 collected in Georgia in 1952 and received from C. O. Johnston was found also to produce a susceptible reaction on seedlings of this stock. The second biotype keying closest to race 104 or race 30 in several tests has been collected widely in Indiana in 1951 and 1952. It produces a 4 type seedling reaction on C.I. 12660 (Warden x Leap) although not attacking Exchange (Warden x Hybrid English) nor the 3369 selections. C. I. 12660 is apparently resistant in the mature plant stage.

The Purdue Station should soon be ready to release hessian fly resistant wheat. In contrast to the current soybean-wheat practice, such a variety should encourage early planting and fall grazing. This practice appears to pose the problem of the need for seedling resistance to avoid damage to this pasture crop and would also suggest the possibility of increased overwintering of local virulent inoculum. The current recommendations of early and increased applications of nitrate would augment this seedling rust threat.

WHEAT VARIETIES RESISTANT TO LEAF RUST AT WINNIPEG, MAN. IN 1951 AND 1952.

A. M. Brown

Table shows the percentage of leaf-rust infection in the field plots at Winnipeg, Man., in 1951 and 1952, on the varieties of common wheat that showed most resistance to this rust. Included also for comparison are the emmer variety Yaroslav, the durum wheat Tremes Preto, and the susceptible common wheat varieties Marquis and Thatcher. There are also listed a number of crosses that have shown very high resistance to leaf rust. The high resistance shown by many of these hybrid lines indicates that the leaf rust resistance of varieties such as Frontana, Frondoso, and Surpresa has been transferred to these lines with little, if any diminution.

Table 8. Wheat varieties and hybrids with 5 percent or less of leaf rust infection when grown under artificial field epidemic conditions at Winnipeg in 1951 and 1952.

Variety		Percentage of infection 1951	1952
Yaroslav emmer	R.L.2629	T	T
Tremes preto (Durum)	" 3111	T	T
Lee	" 2477	T	5
Chinese	" 1815	T	T
Illinois No. 1.B.8	" 1593	T	T
Illinois No. 1			
Chinese^2 x Timopheevi	" 2537	T	T
Exchange	" 1803	0	T
Uruguay	" 1882	T	5
Klein Anniversario	" 2797	T	1
Klein Exito	" 2799	T	1
Klein Titan	" 2393	T	T
Sinvalacho M.A.	" 2800	T	T
La Prevision 25	" 2801	0	T
Surpresa	" 2572	0	T
Fronteira	" 2337	5	1
Frontana x 2265			
Redman^2	" 2520	T	T
Frontana	" 2336	0	0
Redman x Frontana	" 2647	-	0
Rio Negro	" 2802	0	T
Frondosa x Kenya C.I.0862, Cross 3708		T	T
Renacimiento x Kenya C.I.0862,Cross 3708		2	T
Surpresax Kenya C4913, Cross 3707		T	T
Supremo x (Kenya C9906)^2		T	T
(T.dicoccoides x Ae.speltoides) x Austin^2		T	T
Lee x Frontana		1	T
Frontana x Thatcher, etc.		T	T
Sando R.N. 57		0	T
" " 79		0	T
Peru-Supremo		0	T
Mentana-Peru x Kenya		0	T
Kenya-Supremo		T	T
(Mayo x Peru-Supremo) x Peru-Kenya		T	T
Kenya-Marroqui^2 x Peru, etc.		T	T
NS. III-51-34, etc.		0	T
SH. 170 (Pullman)		0	T
SH.198-4 (Pullman)		0	T
P.W. 276. B.C. Jenkins, Saskatoon		0	T
P.W. 292 " " "		0	T
P.W. 327 " " "		0	T
Marquis		70	90
Thatcher		80	90

Table 9. A loss of resistance to leaf rust seems to be indicated by the reaction of the following selections, when observed over a three-year period:

Variety	Percentage of infection 1949	1951	1952
K.338 AA.1.A.2 (I-49-88)	T	5 to 10	10 to 60
K.338 AC.2.E.2 (I-49-89)	T	5	50
K.338 AC.2.E.3 (I-49-90)	T	5	20

Readings made by T. Johnson and G. J. Green

OBSERVATIONS ON LEAF RUST RACE ISOLATIONS IN OKLAHOMA
H.C.Young, Jr., D.F.Wadsworth and A.M. Schlehuber

Leaf rust race isolations made during 1950-1951 and 1951-1952 indicated that the varieties Brevit, Carina, and Hussar were not giving critical differentiation. Consequently, a key has been adopted this year which excludes at least Carina and Hussar. Westar and Westar selection have been included to distinguish two biotypes of race 105, designated here as 105 A and 105 B. These biotypes will attack many Hard Federation hybrids which are among the highest yielding strains in regional tests in the Southwest. The races listed in the key (Table 10) are limited to those which have occurred in Oklahoma during the past three years.

In the 1951 crop season, races 105 (biotypes A and B), 15, and 5 were the most prevalent in that order. Race 9 comprised only 11 percent of the isolates, and there was one collection of race 32. In the 1952 crop season race 15 is the most prevalent among the isolates so far identified. Races 5, 9 and 105 (biotypes A and B) made up the remaining 60 percent in approximately equal numbers.

The distribution of these races on the varieties grown in Oklahoma is of interest (Table 11). Races 9 and 15 dominate the isolates from the varieties Kiowa, Tenmarq and Comanche while race 15 dominates the isolates from Triumph and Pawnee. Wichita and Cheyenne support all three of these races equally. Westar and C.I. 12517 are susceptible only to race 105 which dominates the isolations from these varieties.

This "varietal preference" contributes to intrastate race distribution (Table 11). Race 15 has been the most prevalent race in the north central section for two successive years. In that section a major portion of the acreage is occupied by Triumph and Pawnee. In the northwestern section, where more Comanche and Wichita are grown, races 5 and 9 are more prevalent, and in the Panhandle an increase in the abundance of race 105 is coupled with an increase in the acreage of Westar. The distribution of races in the southern section follows closely the statewide average, as does the distribution of varieties grown in that area.

Table 10. Analytical Key for Identification of Physiologic Races of Puccinia rubigo-vera tritici found in Oklahoma.

- Democrat resistant - 9
- Democrat susceptible
  - Malakof resistant
    - Webster resistant
      - Loros resistant - 15
      - Loros susceptible
        - Westar resistant - - - - - - - - - - - - - - - - - 32
        - Westar susceptible - - - - - - - - - - - - - - - - 58
  - Malakof susceptible
    - Webster resistant
      - Loros resistant - 5
      - Loros susceptible - - - - - - - - -
        - Westar resistant
          - Brevit resistant - - - - - - - - - - - - - - 126
          - Brevit susceptible - - - - - - - - - - - - - 105
        - Westar susceptible
          - Westar selection resistant - - - - - - - -105 A
          - Westar selection susceptible - - - - - - -105 B
    - Webster susceptible - 21

Race	Dem. 3384	Mal. 4898	Web. 3780	Lor. 3779	Wes. 12110	Wes. Sel. 13090	Bre. 3778
9	0-1	4	4	4	0-1	0-1+	1-2
15	4	0	0	0-1	0-1+	0-1	0-1
32	4	0	0-1	3	0-1	0	1-3
58	4	0	0-1	4	3	0-2+	4
5	4	4	0-1	0-1	0-1	0-1+	0-1
126	4	4	0-1	4	0-1	0	0-2
105	4	4	0-1	3+	1-2	0-1	3+
105A	4	4	0-2	3-4	4	0-1	2-4
105B	4	4	0-2	4	4	4	2-2+
21	4	4	4	4	3	0-1	2-4

Table 11. Races of Leaf Rust Isolated from Specific Varieties in Oklahoma

	1951					1952				
	Race					Race				
Variety	5	9	15	105	Total	5	9	15	105*	Total
Kiowa	-	-	-	-	-	-	4	5	1	10
Tenmarq	1	-	-	1	2	1	3	7	1	12
Comanche	2	3	4	1	10	2	4	6	-	12
Wichita	-	-	1	1	2	2	3	5	2	12
Cheyenne	3	1	4	2	10	4	4	5	-	13
Triumph	4	1	2	3	10	2	2	7	1	12
Pawnee	5	-	4	1	10	3	-	9	-	12
Ponca	2	-	3	-	5	4	1	6	2**	13
Westar	1	-	-	9	10	2	1	-	10**	13
C.I.12517	-	2	1	3	6	-	-	1	8**	9
Total	18	7	19	21	65	20	22	51	25	118
Percent	28	11	29	32		17	19	43	21	

* Identified as biotype 105 A

** Includes one collection identified as biotype 105 B.

Races of Leaf Rust Isolated from Specific Localities in Oklahoma

	1951					1952				
	Percent Race:				Total	Percent Race:				Total
Locality	5	9	15	105	Collections	5	9	15	105*	Collections
North Central	23	9	36	32	22	5	8	64	23	39
North Western	43	15	21	21	14	23	30	30	17	40
Panhandle	-	20	40	40	5	20	10	30	40	10
Southern	29	8	25	38	24	24	21	38	17	29
Percent of Total	28	11	29	32	65	17	19	43	21	118

* Includes both biotypes 105 A and 105 B.

LOSSES CAUSED BY LEAF AND STEM RUST OF WHEAT IN MANITOBA IN 1952

B. Peturson

An attempt was made to appraise the damage caused by leaf and stem rust, in 1952, by growing Lee, Redman and Thatcher in sulphur dusted and non-dusted field plots. The plots were grown at Winnipeg in an area unaffected by artificial rust inoculum and became rusted by naturally occurring inoculum only. The plots were sown on May 10, slightly later than the average date of seeding in Manitoba in 1952. Half of the plots of each variety were protected from rust attack by applications of sulphur dust and the remaining ones were left unprotected. The dusted plots remained almost rust free,

while the unprotected plots of all three varieties carried rust infections, in each case, comparable to those occurring on them throughout Manitoba. All three varieties were equally affected by stem rust, each one having an average infection of about 15%. Lee was virtually unaffected by leaf rust while leaf rust infections averaging 80% and 85% occurred on Redman and Thatcher, respectively.

Lee wheat was only slightly affected by the rust infection. Its bushel weight remained unaffected at 61 pounds per bushel for both the treated and untreated plots. Its yield was reduced by 7.7% and its 1000-kernel weight by 5.5%. The reductions in yield and kernel weight of Lee did not quite reach the level of statistical significance. The rust infection caused significant reductions in the yield, 1000-kernel weight and bushel weight of Redman and Thatcher. It reduced the yield of these two varieties, in the order named by 14.2 and 22.7%, their 1000-kernel weight by 17.7 and 20.7% and their bushel weight by 2.4 and 2.0 pounds. There was no significant reduction in the number of kernels per head of any of the varieties. Apparently the losses in yield were due chiefly to reduction in kernel weight.

A careful examination of wheat fields showed that the rust infections on these varieties throughout Manitoba corresponded quite closely to the amount of rust present on them in the rusted plots in the field test. Therefore, it is probable that the differences in yield between the dusted and non-dusted plots closely approximated the actual reductions in yield caused by rust in Manitoba in 1952. From the figures presented it would seem that an estimated yield loss of about 5% for Lee and about 15% for Redman and Thatcher would be a conservative appraisal of rust losses generally. Only negligible amounts of leaf rust occurred on Lee and the loss indicated for this variety was caused by stem rust. Since Redman and Thatcher carried the same percentages of stem rust as did Lee, it may be assumed that 5% or one-third of the 15% loss suffered by these varieties was caused by stem rust and 10% or two-thirds by leaf rust. In 1952, about 90% of the wheat acreage in Manitoba was sown to Redman and Thatcher. Since the total wheat yield amounted to 58 million bushels the probable loss due to rust amounted to about 10 million bushels or 4.5 bushels per acre. The relevant data are given in Table 12.

Table 12. The Effect of Leaf and Stem Rust on Yield, 1000-kernel Weight and Bushel Weight of Wheat Varieties Grown in Field Plots at Winnipeg in 1952.

Variety	Treat-ment	Rust infection in percent Leaf	Rust infection in percent Stem	Average yield per acre bushel	Reduction in yield percent	Weight per 1000-kernels gms	Reduction in kernel weight percent	Bushel weight pound	Reduction in bushel weight pound
Lee	Dusted	tr	tr	53.3		32.6		61.0	
Lee	Rusted	3	15	49.2	7.7	30.7	5.8	61.0	0
Redman	Dusted	5	tr	44.3		36.1		61.4	
Redman	Rusted	80	15	38.0	14.2*	29.7	17.7*	59.0	2.4*
Thatcher	Dusted	5	tr	57.2		27.5		61.3	
Thatcher	Rusted	85	15	44.2	22.7*	21.8	20.7*	59.3	2.0*

* Reductions statistically significant.

Discussion:

Question: Is the situation the same in other provinces as in Manitoba?

B. Peturson: Yes. There was a severe leaf rust infection even west of Regina.

V. A. Dirks: In spite of the fact that leaf rust infection was similar on Thatcher and Redman, you estimated that the damage on Thatcher was greater. Is there any proof of that?

B. Peturson: Kernel weight is a good indication of the damgge. The damage is apparently somewhat greater in Thatcher.

L. R. Waldron: Results at North Dakota support Dr. Peturson's findings.

B. Peturson: Leaf rust infection is usually severe. If the rust comes early, damage is heavy; if the rust strikes late, damage is light. Leaf rust damage is not always obvious. It can only be proved by controlled experiments.

M. N. Levine: The effects of rust on many varieties have been studied under varying conditions at St. Paul. The amount of rust present at a given time is not necessarily an indication of the damage done to a particular variety. It is important to know when rust appeared, and how rapidly it developed, and the length of association of rust with host, or the "seasonal rust load". Some varieties are more tolerant of rust infection than others. Mida may suffer less damage than Cadet with the same or greater rust infection or seasonal rust load. Damage by leaf rust to Thatcher may be up to 50% at St. Paul. Yield, kernel weight, number of kernels, and even size of stem may be affected, but length of head is not affected.

T. Johnson: All leaf rust investigators are using standard differential hosts, and accessory hosts important in their own areas. The old differentials should be kept to retain historical perspective, and information on the new or accessory differentials should be circulated. This should be easy, because there are relatively few workers concerned. They should not wait for formal meetings to exchange information. It is obvious that leaf rust investigations will have to be continued.

Monday Evening, January 5.

Dr. J. G. Taggart, Deputy Minister of Agriculture for Canada, presided at a banquet given to all those attending the Conference by the Government of Canada. After Dr. Taggart's official welcome, Dr. K. W. Neatby spoke on "Milestones in Rust Research". Dr. E. C. Stakman, Chief of the Division of Plant Pathology, University of Minnesota, representing the visiting delegates, spoke, among other things, of the problems of research in biology. Hon. D. L. Campbell,

Premier of Manitoba, welcomed the Conference to Manitoba. Dr. J. G. Harrar, Deputy Director of Agriculture for the Rockefeller Foundation, made a speech of tribute and a presentation to Dr. Stakman, who is due to retire in 1953, on behalf of Dr. Stakman's many colleagues and students in the United States and Canada. Dr. W. F. Hanna, Chief of the Division of Plant Pathology for Canada, added special greetings to Dr. Stakman on behalf of the Canadians.

Tuesday Morning, January 6.

Dr. R. F. Peterson was General Chairman for the session devoted to "Progress in breeding for resistance to stem rust and leaf rust in wheat".

BREEDING FOR RESISTANCE TO 15B
L. R. Waldron

This report has to do with recent results from crosses made between Lee and sibs of Mida. The sibs possess about the same susceptibility to 15B as Mida and so if offspring of the crosses show resistance this exceptional fact is of importance. The 2 sib parents used are Ns 3175 and Ns 3264. Plant selections from Lee x 3264 were grown in single plant rows in 1951, some of them from single plant greenhouse increases. The 1951 rust epidemic was not heavy and a considerable number of them were sent to Brawley for increase. Preliminary to this 5-gram single plant samples were sent to University Farm to be tested in the mature plant induced 15B nursery during the summer of 1951. While the majority were listed as susceptible or moderately so, enough were listed as trace or as 5 to 10R to be encouraging. Among the resistant selections were those given the Ns numbers 4020 to 4024. As these had been increased at Brawley enough seed was available for field plot tests in 1952. These were grown in triplicate with Lee, Mida and Thatcher as checks. The rust epidemic was more severe in 1952 than in 1951. Stem rust on the 5 selections was listed from 5 to 10 percent while readings on the checks was from 50 to 75 percent, resp., with Mida scored 65 to 75 percent. Leaf rust on these was estimated from 2 to 5 percent with Lee at 15 and Thatcher 50 to 60. Yields were disappointing for the selections as they averaged 14.2 bushels against an average of 13.8 for the checks. The selections were also in rod-row trials and there also their yields were about the same as those of the checks. The results seemed to be convincing that while resistance to 15B was evident, satisfactory yield was lacking.

From the other cross, Lee x 3175, the earlier trials were with the bulk increase, Ns 3880. A sample was tested at Beltsville with mature plants against 15B with a scoring of HR. At Ciudad Obregon the reading was TS and, at College Station, Texas, it was MS. At Fargo in the nursery in 1950 and in 1951, 3880 had evidently less rust than was carried by Lee grown comparably.

The bulk 3880 was grown cooperatively by a farmer near Fargo with 7 other selections and Mida and Lee with the rows quadruplicated.

A sprinkling system was available and with its use a severe epidemic resulted, almost certainly that of 15B. The 40 units were cut by Mr. Kapaun and brought to Fargo for threshing. Stem rust was noted on all the samples but estimated percentages were not taken. Threshing was done on a Vogel machine and weights taken. Data on only 5 of the 10 units are given, enough to demonstrate marked resistance against the checks.

Selection	Yield	Test Weight	Kernel Weight
Ns 3880	44.3	56.7	24.7
8.15.21	43.6	55.4	24.1
8.15.18	38.2	57.3	22.0
Lee	30.5	53.8	22.9
Mida	18.7	45.1	15.2

Lee shows a reduction of yield of over one-third from 3880 and a marked defect in test and kernel weight. The loss in yield for Mida was nearly 60 percent and an extreme drop in kernel weight to 15.2 from the normal 35 mg.

In 1952, 230 selections from 3880 were seeded at Fargo in 4 nursery trials from seed of single plant selections increased at Brawley. The late seeding of May 20 allowed a good rust epidemic to develop. Differences in yields were striking as follows:

	Bush.
Four highest of 3880	32.9
Four lowest	16.5
Four Lee checks	24.1
Four Mida checks	22.7
Four Thatcher checks	19.6

Fifteen top yielders from each of the 4 nurseries with an average yield of 27.3 bush. were micromilled and baked with the results generally satisfactory. Forty of these sixty are now under increase at Brawley.

The above indicates that unlooked-for and satisfactory selections may be obtained from parents not of an a priori promise for securing worth-while results.

PROGRESS IN BREEDING FOR RESISTANCE TO 15B STEM RUST

North Dakota Agricultural College Experiment Station
Fargo, North Dakota

Glenn S. Smith

Several wheats have been used as 15B stem rust resistant parents, Kenya 350, Kenya 360 H, Kentana, Lerma and Kenya 338. To date, the most promising has been Kenya 338, because of its good 15B resistance and also its resistance to leaf rust.

F_2 populations of Thatcher x Kenya 338AC and Rushmore x Kenya 338AC crossed by Dr. Bayles were grown at Fargo and Langdon last

summer, and the seedling reaction to 15B stem rust of the F_3 progenies was recently determined by Mr. E. A. Schwinghamer.
results.

Seedling reaction to 15B stem rust of F_3 progenies in relation to field reaction (15B) of F_2 plants of Thatcher x Kenya 338 and Rushmore x Kenya 338. (Temp. 75-80°F)

Seedling reaction of F_3 progenies	Percent rust on mature F_2 plants 0	T	10	20	30	40	50	60	F_3 Totals
Thatcher x K 338									
Resistant	5	14	3						22
Segregating	5	32	25	15	3	2	3		85
Susceptible	2	6	7	8	16	14	21	1	75
F_2 totals	12	52	35	23	19	16	24	1	182
Rushmore x K 338									
A-3									
Resistant	10	20	5						35
Segregating	23	61	19	21	14	6	1		145
Susceptible	1	4	1	4	11	11	5		37
F_2 totals	34	85	25	25	25	17	6		217
A-4									
Resistant	12	16	1	2	1				32
Segregating	22	32	20	4	6	1	1		86
Susceptible	1	6	3	5	6	10	6		37
F_2 totals	35	54	24	11	13	11	7		155

The inheritance of resistance in Kenya 338 cannot be clearly determined from the above data. There appears to be a difference in the genes involved in crosses with Thatcher and with Rushmore. In the Rushmore x Kenya 338 cross, about equal numbers of homozygous resistant and susceptible progenies were recovered. Relatively high temperatures in the greenhouse may have affected the seedling reactions. The important observation for the plant breeder is that relatively many F_3 progenies appear homozygous resistant to 15B. It appears that the Kenya 338 resistance will not be difficult to recover in further crosses and back-crosses.

Resistance to 15B from Kenya 338 appeared to be inherited as a dominant character, as indicated by the fact that over half the F_2 plants fell in stem rust classes 0, T and 10%. F_3 seedling segregation also indicated dominance of resistance in most progenies.

In another cross, Lee-"Mida" x Kenya 338AC, Mr. Schwinghamer determined the seedling reaction to 15B stem rust of the F_2 population. This again demonstrated the dominance of 15B resistance with nearly 3/4 of the F_2 plants resistant. The F_1 plants were highly resistant in the field this summer. F_2 seedling reaction was as follows:

Resistant F_2 plants	246
Susceptible F_2 plants	95
Doubtful F_2 (Type 1 or 3)	33
Total	374

BREEDING WHEAT FOR RUST RESISTANCE IN WISCONSIN
(Cooperative Project of U. S. Department of Agriculture and Wisconsin Agricultural Experiment Station)

R. G. Shands

It was estimated that stem rust reduced yield 1.5% in spring wheat and .5% in winter wheat in 1952. Stem rust was light in southern Wisconsin and increased in severity northward. Station averages of infection severity for 17 spring varieties were: Madison 5.5%, Marshfield 7.3%, River Falls 9.2%, Ashland 23.1% and Sturgeon Bay 15.6%. Presumably race 15B was present, but race identification data are not yet available. Yield loss from leaf rust was estimated at 1% in spring wheat and none in winter wheat.

Greenhouse tests have not been used for selection or for determining varietal reaction to rusts as yet.

Spring Wheat

Severity of stem rust infection for 17 varieties at 5 stations ranged from 1 to 49% as shown in the table. Four lines of H194 and H195 with resistance to loose smut, mildew, and hessian fly and moderate susceptibility to leaf rust, averaged 3 or 4% stem rust and have yielded well. Two selections of Henry x Surpresa showed good resistance to leaf and stem rusts in the field and have yielded well for 2 years. H306 (Thatcher x a winter Timopheevi derivative) showed good resistance to both rusts. Perhaps the most promising is Wis. No. 250 which has shown resistance to the rusts, loose smut, mildew and hessian fly as well as satisfactory straw and yield for 2 years. A small increase of Wis. 250 may be grown in 1953.

Average rust percentages and yields of spring wheats tested at 5 locations in Wisconsin in 1952.

Variety	C.I. No.	Stem rust Ave. % 1/	Leaf rust Ave.% 2/	Yield 1/ Ave.bu.
Henry	12265	8	6	23.0
Sturgeon	11703	9	29	22.5
Thatcher	10003	18	54	15.3
Rival	11708	30	39	16.8
Mida	12008	25	25	15.2
Lee	12488	14	T+	21.7
Thatcher x W38-Hope H194-28-3		3	24	24.8
do H194-41	12649	3	26	25.4
do H149-79-7		4	26	25.7
do H195-45	12484	3	16	27.1
1764 x Henry N.2211	12733	49	8	20.7
Henry x Cadet N.2239	12779	19	T+	20.7
Thatcher x Surpresa II-39-8	12641	15	1	24.5
Henry x Surpresa H305-2		2	T	27.9
do H305-10		1	T	25.4
Thatcher x H143 H306		1	1	22.1
Henry x That.-W38-Ill.1-Hope H405c-7-1-1-1 Wis.250		2	T+	26.5

1/ Ave. at Madison, Ashland, Marshfield, Sturgeon Bay, and River Falls.
2/ Ave. at Madison, Ashland, Sturgeon Bay, and River Falls.
Tested as 5 replicates of 3-row plots 18 feet long (Madison 4 replicates)

A few F_6 lines from Frontana x Thatcher-W38-Hope with white glumes are ready for yield tests. They have shown excellent leaf rust resistance and fairly good stem rust resistance in the field. F_7 lines from Reward x C.I. 12632 (the latter from (Ill. 1 x Chinese)^2 x Timopheevi) are ready for yield tests. These are early and are resistant to the rusts.

Kenya 338 A.C.2.E.2.C.I. 12880 and M-E-R[3] R.L. 2564 have been used in more recent hybrids. The Kenya variety with semi-solid straw was chosen as a parent because of its moderate resistance to leaf rust and mildew in addition to stem rust resistance. In 1952 F_2 plants were selected for resistance to rusts in the following:
(1) R.L. 2564 x Henry-W38-Hope.
(2) [(Henry-W38-Hope) x Thatcher - Surpresa] x Kenya C.I. 12880.
The second hybrid appeared more promising for stem rust resistance than the first.

A marked difference was observed in stem rust reaction of the 2 T. timopheevi selections in a 1952 field test. P.I. 94760 C.I. 11802 was appreciably more susceptible than P.I. 94761. Yaroslav was much more resistant than Vernal emmer. No. 58, P.I. 134704 from Afghanistan was very outstanding for straw strength in a 5-foot row.

Winter Wheat

Improvement of winter wheat includes several agronomic characters besides breeding for resistance to leaf rust, stem rust, loose smut and bunt. Septoria leaf blotch has caused damage during the past three years while mildew is important in occasional years.

Hope and T. timopheevi are the main sources of stem rust resistance. Hope derivatives are not as promising because of brown necrosis. The lines C.I. 12661 and C.I. 12662 derived from Ill. No. 1-Chinese-Timopheevi-Ped. 2 Turkey x Minturki, as well as similar lines, have been used extensively in recent years for stem rust resistance. The association between lateness and resistance was broken in these lines. They are more or less suceptible to leaf rust and loose smut. F_2 field tests from Rex-Rio C.I. 12246 x C.I. 12662 showed a ratio of 5.15 R to 1 S for stem rust. A similar test for C.I. 12662 x Blackhawk segregated 7.3 R to 1 S. F_4 lines of the latter showed high resistance to leaf and stem rusts in 1952 field tests. As yet the Kenya stem rust resistance has not been included in the program. Selections have been made in some bulk hybrids obtained from Kansas. McMurachy-Exchange-Redman[3] was one parent of the bulks while Cheyenne, Comanche, Pawnee, Tenmarq, Triumph, and unnamed lines were the other parents.

The main sources being used for leaf rust resistance are Blackhawk, Shansi C.I. 12612, D449, and Hope-Hussar C.I. 11682.

Discussion:

R. G. Shands: We are testing large amounts of foreign material with which we are not familiar. Conditions were unusual at Madison this year, and bacterial diseases, Septoria, and anthracnose (new at Madison) were observed on the group of 435 wheats from Dr. Bayles. Suceptibility to these diseases may be characteristic of some of these varieties. We can perhaps select for resistant types if we made crosses with older varieties. We may be able to avoid the difficulty by using older wheats with simple 15B resistance. (In reply to a question, Dr. Shands stated that the cross Henry x Thatcher was not resistant to Hessian fly).

W. A. F. Hagborg: Were bacterial diseases a major problem in Wisconsin?

R. G. Shands: The leaves were fine on Frontana but there was some possible bacterial infection on the seeds. It showed black point and a graying in the groove of the kernel. Bacterial infections were noticed particularly in the nursery, not all over the state.

PROGRESS IN BREEDING FOR STEM AND LEAF RUST RESISTANCE IN MINNESOTA

E. R. Ausemus, D. W. Sunderman, K. J. Hsu, and D. H. Smith

The breeding program is being conducted in the greenhouse where certain races or collections of races are used and in the field under both artificially induced and natural infection. In the greenhouse seedling tests conducted during the winter of 1950-51, a mixture of isolates of stem rust race 15B was used to test the varieties that were grown in the field trials and the plants selected from the field Rust Nursery during the previous summer. These were tested at high (80-85°F) and low (60-70°F) temperatures. Some of the more promising lines were also inoculated in the 5 to 6 leaf stage and again as adult plants. Approximately 2,200 selections were tested during this winter. In 1951-52, approximately 2,500 selections were tested to 15B at high temperatures in the seedling stage. The lines or plants showing resistance were tested at room temperature in the adult plant stage.

In the field Rust Nursery at St.Paul, a mixture of races of leaf and stem rust were used to create the epiphytotic artificially. In 1951, 33 races of stem rust and 16 of leaf rust were used, while in 1952, 60 races and biotypes of stem rust and 12 races of leaf rust were used. In addition, the more advanced materials are being tested under natural conditions at 7 locations in Minnesota and in several special tests in other states, Canada, Mexico, Latin America and other locations to be discussed later.

The results obtained on a few of the parental varieties in the greenhouse and field tests in Minnesota are given in Table 13.

SPRING WHEAT

Stem Rust

The main sources of resistance to race 15B used in our breeding program have been Kenya 58, Kenya 117A, Frontana, Kenya 58 x Newthatch N.S. No.II-44-29, Mida x Kenya 117A. N.S. No. II-44-22, and various other Kenyas and Kenya derivatives. These varieties, with the exception of Frontana have shown resistance to 15B in the greenhouse, either at room temperature, or higher temperatures, or both, and to the races present in the Rust Nursery.

The more promising advanced material is derived from a cross of Timstein x Henry made in 1944 and of Frontana x Thatcher made in 1946. These derivatives do not have seedling resistance at the higher temperatures, but they did show fair resistance to the stem rust races present in the Rust Nursery. They are also resistant to leaf rust. Three selections from these two crosses, Timstein x Henry N.S. No. II-44-65, Frontana x Thatcher N. S. No. II-46-13 and II-46-53 have yielded as good or better than our present commercial varieties and are satisfactory for milling and baking in the tests thus far conducted.

Kenya 58 x Newthatch II-44-29 and Mida x K117A II-44-22 were crossed with Frontana in 1950 in an attempt to combine leaf and stem rust resistance. Large F_3 populations were grown in the Rust Nursery in 1951. Plant selections made in the field for both leaf and stem rust were tested in the seedling stage at high temperatures to stem rust 15B during the winter of 1951-52. Selections from a cross of Mida x Warden-Hybrid English were also tested. A number of these selections which were resistant in the seedling stage to 15B and resistant to both rusts in the field are being increased at Brawley, California this winter.

In addition, a number of selections from a Lee x Frontana cross have shown both seedling and field resistance and have been placed in the preliminary yield trials. Backcrosses using Lee, Mida, Thatcher and Newthatch as the recurrent parents are being made with some of the above mentioned spring wheats in an effort to combine stem and leaf rust resistance. Lines and plants resistant in the field in 1952 are being tested in the seedling stage to several races and biotypes of stem rust in the greenhouse this winter.

Leaf Rust

The main sources of leaf rust resistance used in our breeding program have been Timstein, Surpresa, Lee, Klein Titan, Frontana, Rio Negro, and certain of the Kenyas and their derivatives. These have been crossed with the stem rust resistant varieties in an effort to obtain a suitable variety with both leaf and stem rust resistance. Crosses between the various leaf rust resistant varieties were also being made for the purpose of obtaining

varieties which are resistant to a greater number of leaf rust races.

Some of the crosses which have been made and the number of lines from each resistant to both leaf and stem rust in the Rust Nursery are as follows:

Cross	Number of resistant lines
Frontana x Mida-Kenya 117A II-44-22	166
Frontana x Kenya58-Newthatch II-44-29	242
Lee x Frontana	5
Frontana x Thatcher	3
Frontana x Bobin^2 Gaza x Premier II-39-2	16
Frontana x Rio Negro	9
Frontana x Frondosa-Chinese Progress III-46-14	19
R.L. 2632 x Mida-Kenya 117A II-44-22	7
Klein Titan x K58-Newthatch II-44-29	11
K58-Newthatch, II-44-29 x R.L.2632	10
K58-Newthatch, II-44-29 x R.L. 2327	6

Thatcher and Mida used as recurrent parents are being backcrossed to certain of the above leaf rust resistant varieties in an attempt to combine leaf rust resistance with the desirable characters of the recurring parents. These will then be crossed with stem rust resistant strains of the same variety.

WINTER WHEAT

In the winter wheat program at this station the more desirable winter hardy wheats such as Minturki, Minhardi, and Minter or their derivatives have been crossed with Blackhawk, (Mediterranean-Hope-Tenmarq) x Kenya Sel. R.L. 1373, 47BN3345-5; (Renancimento-Clarkan-Kawvale) x (Marquillo-Oro) 47AN3489; Oro-Mediterranean-Hope 42 RN3802-43-1, and Wabash-American Banner, 3369-61-1-1-6-1 in an attempt to get greater leaf and stem rust resistance. A large number of F_2 plants from these crosses were winter-killed in 1951-52.

A backcrossing program, using Minter, Minturki, and Blackhawk as recurrent parents in crosses with leaf rust resistant spring wheat varieties Frontana and Klein Titan and stem rust resistant varieties Kenya 58 and K117A is being carried in an attempt to get winter hardy wheats with greater leaf and stem rust resistance. Agropyron-wheat derivatives are also being used as non-recurrent parents in crosses with Minter.

Table 13. Reaction of certain spring wheat varieties to leaf and stem rust in the Yield and Rust Nursery at St.Paul, Minnesota in 1952, and at various stages and temperatures in the 1950-51 greenhouse tests.

Variety	N.S. No.	Reaction in Greenhouse to stem rust race 15B: Seedling 80-85°	Seedling 60-70°	5-6 leaf 70°	Adult Plant 70°
Thatcher		VS	S	S	S
Rival		VS	S	S	S
Mida		S	S	S	S
Lee		S	S	S	S
Timstein		S	MR	MS-S	MS
Frontana		MS	MR	MR	S
Kenya 58		MR	R	0	R
Kenya 117A		R	MR	MR	0
Kenya 58 x Newthatch	II-44-29	R	R	R	R
Mida x K117A	II-44-22	R	MR	R	R
K58 x Newthatch	II-44-11	R	MR	MR	MR
Frontana x Thatcher	II-46-13	S	MR	–	R
"	II-46-53	S	R	R	MS
Timstein x Henry	II-44-65	MS	R	–	MS
Thatcher x Surpresa	II-39-8	S	–	S	–

Variety	N.S.No.	Field Reaction University Farm: Stem Rust, Rust Nursery	Stem Rust, Yield Trials	Leaf Rust, Rust Nursery	Leaf Rust, Yield Trials
Thatcher		60S	20SR-S	80	65
Rival		70S	60SR-S	80	70
Mida		60S	45SR-S	70	60
Lee		70S	40SR-S	15	5
Timstein		60S	40SR-S	T	T
Frontana		15R-S	20SR	T	T
Kenya 58		10R-SR	5R	70	60
Kenya 117A		10R-S	5R	60	60
Kenya 58 x Newthatch	II-44-29	5R	TR	50	70
Mida x K117A	II-44-22	5R	5R	80	60
K58 x Newthatch	II-44-11	5R	–	–	–
Frontana x Thatcher	II-46-13	20SR-S	TR	T	T
"	II-46-53	30SR	10R-SR	T	T
Timstein x Henry	II-44-65	25R-SR	15R-SR	5	3
Thatcher x Surpresa	II-39-8	60SR-S	50R-S	20	1

PROGRESS IN BREEDING WHEAT FOR RESISTANCE TO STEM RUST AND LEAF RUST

Dominion Laboratory of Cereal Breeding, Winnipeg
A. B. Campbell

For some years the breeding program at the Dominion Laboratory of Cereal Breeding, Winnipeg, consisted mainly of exploiting as fully as possible the material from crosses involving both McMurachy (R.L. 1313) as a source of stem rust resistance (including 15B), and Exchange (R.L. 1803) as a source of leaf rust resistance. As early as 1939 the cross McMurachy x Exchange was made and since that time we have been using the hybrid R.L. 2265 which was selected from that cross.

A large number of hybrids of the following parentage have been tested:

R. L. 2265 x Redman
" x $Redman^2$
" x $Redman^3$
Thatcher x (R.L. 2265 x $Redman^2$)
Mida-Cadet x (R.L.2265 x $Redman^2$) (U.S.D.A. 1831)
Lee x (R.L. 2265 x $Redman^3$)

C. T. 186, from the cross R.L. 2265 x $Redman^3$, is the most advanced of this material. We hope that its quality will prove as satisfactory as its agronomic performance and that it will be licensed within the next few months.

The disadvantage of the McMurachy type of stem rust resistance is that it breaks down at high temperatures. With this in mind we have endeavored to combine additional genes for resistance in crosses such as Frontana x (R.L. 2265 x $Redman^2$) from which we got R.L.2520. This line is much more resistant to high temperature breakdown, and also has greater leaf rust resistance.

R.L. 2520 has been used in crosses with Redman and to a limited extent with Thatcher and Lee. We are now testing a large number of such hybrids for agronomic and quality characteristics.

Altogether there are several hundred such hybrids which are approaching the final testing stage. Many will be discarded on the basis of 1952 data, but the remaining ones should be very promising.

We have been testing a large number of introductions in rust nurseries each year. The Kenya wheats have shown considerable resistance to race 15B. Kenya 338.AC.2.E.2 has been used to a considerable extent in a backcrossing program using Redman, Thatcher and Lee as recurrent parents. While at first there appeared to be a single main dominant gene for 15B resistance, it has become more and more difficult to maintain the resistance as backcrossing has proceeded. We now have material with up to five doses of the recurrent parents, but whether the 15B resistance is adequate will not be known until further tests have been made. We are also carrying along material with one, two, three and four doses of the standard varieties.

The leaf rust program at present is being neglected somewhat in concentrating on getting adequate stem rust resistance, but we are still using Exchange and Frontana genes to satisfy this requirement.

Discussion:

J. Unrau: How important is the breakdown of C. T. 186 at high temperatures?

T. Johnson: I don't think we can say anything very definite about it. We hoped that the resistance would not break down. We assume C.T. 186 has the same stability as McMurachy. The chances are that it should be very reliable in Canada, although the U. S. people do not think it is very good.

PROGRESS IN BREEDING WHEAT FOR RUST RESISTANCE AT THE UNIVERSITY OF SASKATCHEWAN

B. C. Jenkins

The development of spring wheat varieties resistant to rust has long been an objective in wheat improvement at the University of Saskatchewan. The accomplishment of this objective is greatly facilitated by the annual production of an artificial epiphytotic on irrigated land in the Field Husbandry Investigation field. The regular breeding procedure is to grow bulk F_2 populations under rust epidemic in the nursery. Resistant plants are selected at harvest time, threshed singly and prepared for individual plant rows in F_3 (60 kernels per $11\frac{1}{2}$ foot row). Aside from the occasional exception, the F_3 and subsequent generations are grown in hybrid nursery on dry land. Once in a while F_3 rows are grown in the rust nursery. Ordinarily, however, after resistant plants are selected in the F_2 no further check on rust reaction is made until lines are entered into preliminary yield tests. It is obvious that this procedure makes possible the entry into yield tests of heterogenous and susceptible material. In actual practice this does not appear to be an insurmountable complication since reselections can be made from heterogenous lines and the rare exceptional susceptible line can be used as the recurrent parent in a backcross program. Many thousands of plant lines are handled by the pedigree method each year. Rigid selection for vigor and agronomic characters is made possible by having a check variety every fifth row in the nursery. Experience has shown that this method leads to an abundance of high yielding lines in yield tests.

Following the release of Apex in 1937 efforts were immediately directed toward further improving the variety by making another cross to Marquis. After a number of years of selection and testing, the present foundation stock of the variety, known as Apex 2177, was developed. Concurrently, a great many segregates from the cross Comet x Apex were exploited. Several of these, but particularly CA-11, proved to be superior in yield and agronomic characteristics.

Unfortunately none of the lines had a sufficiently high protein to meet quality standards. The next step was to cross the best Comet-Apex lines with Thatcher. This cross has given rise to a large number of very promising segregates known as our CA-T lines which are now in preliminary and advanced yield tests. To anyone familiar with the varieties in question, it is apparent that their exploitation could produce improved varieties with resistance only to stem rust (excluding race 15B). No leaf rust resistance is involved. Consequently, early in the forties the variety Red Egyptian was crossed with Thatcher and Red Bobs. Later, other varieties such as Lee, Chinook, and C.T. 609 (Mida x Cadet) were involved in the crossing. Still later, Professor Shebeski brought in many segregates from the cross P.W. (Chinese Spring$_2$ x A. elongatum) x Redman. In addition to the CA-T lines these crosses are now providing promising lines in preliminary and advanced yield tests. Unfortunately, with only one exception, our present hybrid lines are susceptible to race 15B of stem rust. This realization does not cause us undue alarm because of the fact that the major economic area of wheat production is thus far free of race 15B and furthermore any release of a 15B resistant variety will provide a barrier for the rust and continue to insure the security of a large area.

A distinct alteration in our spring wheat breeding program has recently been made possible as a result of a grant for "Genetic and Cytogenetic Studies in Wheat" from the Canada Department of Agriculture. Material from this research program, discussed more fully at another section of this Conference, will provide a constant flow of potential varieties with resistance to leaf rust and all races of stem rust. We are grateful to the Department of Agriculture for making possible this great opportunity in wheat breeding.

WHEAT IMPROVEMENT IN SOUTH DAKOTA

V. A. Dirks

The purpose of the spring wheat improvement program at the South Dakota Experiment Station is to develop varieties that will produce high yields of good quality grain under the range of environmental conditions occurring and expected in the state. These conditions include three major fungus diseases; stem rust, leaf rust and scab. New varieties will have to combine resistance or tolerance to all three of these diseases, since susceptibility to any one of them might easily offset plant breeding gains made by resistance to the other two. At present, lines are available at this station which have shown a considerable measure of resistance to stem rust, scab and resistance to leaf rust. Several of these are now being tested in larger lots; two are undergoing experimental increase (Rushmore^2 x Surpresa 36 and Rushmore^2 x Surpresa 114).

Breeding for stem rust resistance is aimed at location of high levels of morphologic or physiologic tolerance to this disease. A number of lines have shown consistent low levels of infection in the field, under very severe disease conditions. Some of these lines are known to have an unusual amount of mechanical tissue in their

stems. Transgressive segregation for levels of rust resistance higher than either parent have been noted in the progenies of some crosses. This suggests the presence of minor genes for rust resistance in many varieties, which could be concentrated by breeding in the ultimate hope of developing resistance of a high order of effectiveness and stability. Backcrossing is being used in relation to these two methods to incorporate the Kenya resistance to race 15B in varieties and selections that have shown some measure of field tolerance to stem rust. Such an approach should reduce the vulnerability of potential varieties when the pathogen, by mutation, selection and hybridization, is able to attack varieties carrying major genetic factors for resistance to Race 15B.

Leaf rust resistance is extremely important under South Dakota conditions. The resistance of the South American introduction, Surpresa, has been used extensively at this station, and has been very satisfactory so far. Other sources of resistance now being used have resulted from transgressive segregation in crosses of susceptible parents.

Breeding for resistance or tolerance to scab has been a major problem. Lines derived from crosses of Rushmore with Ill. No. 1, Java, Bluestem and Surpresa respectively, have shown as low an incidence of scab as some of the best available parental varieties. No lines have yet been found that are entirely free of scab under conditions as severe as those of 1951 and 1952. Resistant lines from different crosses are being intercrossed in an attempt to reach a higher level of scab resistance.

Discussion:

Question: Does the use of tolerant varieties reduce the pressure on the rust organism?

V. A. Dirks: That depends on the specificity of the rust organism.

R. F. Peterson: This is the same approach that is used in Europe. They have bred for high-yielding varieties with moderate resistance. The wheats are vulnerable when the epidemic occurs.

SOURCES OF RESISTANCE TO STEM RUST RACES 49 and 15B

Alfredo Campos 1/, Eugenio Duarte 1/ and Manuel Rojas 1/

The widespread appearance of stem rust race 49 in Mexico during 1952 necessitated testing the advanced generation breeding material, Commercial, and parental varieties for resistance to this race. Prior to September 1952, major emphasis was devoted to developing wheat varieties with resistance to stem rust races 17, 19, 38, 56, 59 and 15.

The field collection of race 49 used in the greenhouse inoculation tests herein reported was isolated from a collection made on Kenya C9906 (RF 324) near Saltillo, Coahuila in August 1952. This isolate was purified twice before it was used in these greenhouse inoculation tests.

The data recorded in table 14 include the reaction of 83 lines and varieties to:

1. Race 49 in both the seedling and the adult stage.
2. Race 15B (isolate from South Central Mexico which differs from the biotype in Sonora) in the seedling stage.
3. Race 56 in the seedling stage.
4. A race or biotype, tentatively identified as race 125 in the seedling stage.

The last race on the basis of its reaction on the 83 varieties and lines appears to be similar to or a biotype of, race 49. It was isolated originally from a culture which was predominantly race 49. On the differentials at temperatures of 60-75°, this isolate appears to be race 125, but at slightly higher temperatures it "keys out" as race 56.

SUMMARY

In general the data on race 49 can be summarized as follows:

1) Many of the Kenya varieties and 15B resistant varieties which carry Kenya type of resistance are very susceptible to race 49.

2) All of the Kenya varieties which are commonly being used in breeding programs, with the exception of Kenya 338 AC.2E2 P.I. 12880 which is highly resistant, are very susceptible to race 49.

3) McMurachy is very susceptible.

4) Egypt Na 101 is very susceptible.

5) Egypt Na 95 is very resistant to race 49.

6) Virtually all of the commercial hard red spring wheat varieties are resistant to race 49, this includes Newthatch, Thatcher, Mida, Lee and Hope, as are also the Brazilian varieties Frontana and Rio Negro, and the Australian varieties Timstein and Gabo.

7) Virtually all durum varieties are resistant to race 49.

8) Crosses involving Kenya for resistance to race 15B, with spring wheats which contain Hope resistance apparently often give segregates which cover both race 15B and race 49.

9) Although there are many sources of resistance to race 49 it is likely to cause trouble in breeding programs where resistance to race 15B is being obtained from Egypt Na 101, McMurachy or Kenya wheats.

1/ Mexican Department of Agriculture - Oficina de Estudios Especiales.

Table 14. Greenhouse Reaction of 83 Parental Wheat Varieties and Lines to Stem Rust Races 15B, 49, 125 and 56.

	P.I. or C.I. No.	Race 15B 1/	Race 49 Seedling Stage 1/	Race 49 Adult Stage 1/	Race 125 2/	Race 56 Typical
Egypt Na 95	12894	0;1	0	I 3/	0	3 -
Egypt Na 101	12100	0;1	4 + +	S	4 + +	3 -
Frontana	12470	3-	1 + +	R	0;1	2
Gabo	12795	4 +	1 -	R	0;	0
(Ill.-Ch)[2] Tim.	12633	4 +	1 -	I	00;	0;1
Kenya Governor	92472	0;1	4 +	S	4 +	3 -
Kenya Standard	92473	0;1	4 +	S	4 +	3 -
K.59.A 31B 18(L) C 9724	117767	0;1	4 +	S	4++	
Kenya 58	12471	0;1	4 +	S	4 +	3 +
Kenya 117A	12568	0;1	4 +	S	4 +	3 +
Kenya C9906 RF 324		0;	4 + +	S	4	0
K 338 AC.2.E.2	12880	0;1	0;1	I	0;	0;
Lee	12488	4 +	0;	I	0;	1 +
Maria Escobar	150604	2.3	3 +	S	3 +	3 +
McMurachy	11876	4	4 +	S	4 +	4 -
Supremo 211	12531	3 -	2 -	I	2 + +	0
Tremez Molle	56258-1	x -	1 - 3 +			
			3 - 0	R	3 C	2 -
Tremez Preto	56256-3	x -	6 - 3			
			7 - 0	R	3 C	1
Tremez Rijo	56257-1	x -	x +	R	x +	2 -
Tremez Rijo	7066	x -	x +	S	x +	2 -
No. 466 4-M-M-M	159098	x -	3 - 4			
			4 - 0	I	4 +	0;
Africa No. 43	159106 (5- / 2- 3)	0;1	3 +	S	4 +	3
Beladi 116	133457	3 -	0;	I	0;	
Beladi	57662	3 -	0;	I	0;	
Beladi 116	153777	3 -	0;	I	0;1	
Gaza 277	12616	3 -	0;	I	0;1	
Golden-Ball x Iumillo Mindum RL.1714	12924	3 -	4 - 3 -	R	0;1	
			7 - 0			
Barrigon Z. 48	Mexico	4	0	R	0;1	1 - 3
						7 - 0

1/ Temperature during tests 65-85°F

2/ This keys out race 125 at low temperature and race 56 at higher temperatures.

3/ I - Very resistant - R - Resistant - S - Susceptible

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Table 14 – cont'd.

	P.I. or C.I.No.	Race 15B 1/	Race 49 Seedling Stage 1/	Race 49 Adult Stage 1/	Race 125 2/	Race 56 Typical
Mentana	12448	2 –	2 + +	R	1 +	
Timopheevi	11802		0	I	0;1	
Kentana 48	Mexico	8 – 0; 2 – 3 +	3 – 4 7 – 2 + +	1 – S 5 – R	2 – 4 10 – 2 +	
Kentana 51	"	0;1	2 +	1 – S 3 – R	2 + +	
Kentana 51A	"	0;1	2 + +	3 – R 2 – I	2 + +	0
Kentana 51B	"	0;	2 +	R	1 – 3 + 8 – 2 + +	0
Kentana 52A	"	0;1	4 +	S	4 +	0
Kentana 52	"	0;	4 +	S	4 +	0
Lerma 50	"	3 –	4 +	S	4 +	0
Lerma (Enciso)	"	3 –	4 +	S	4 +	0
(K-M^2) ME 1442-1C-1C-3C-1Y-2C	"	1 +, 2	4 +	S	4 + +	
Supremo 51A (Supremo x Kenya)	"	0;1	4	2 – S 4 – R	4 + +	0
Supremo 51 (Supremo x Kenya)	"	0;1	3 – 4 5 – 0	4 – S I – R	2 + +	0
Yaqui 50	"	4	6 – 4 3 – 0	I – R	3,4	2 + +
M 588 – Th Tab # 5 (Cross 707)	"	4 +	2 +	R	4 +	
Frondoso – Kenya 9906-Gular (Tabl Var 718)	"	x	0	I	2 – x – 3 – 3 4 – 2 + +	
(E-T) (ME^2-S) 2158-2C-6Y-1C	"	x	4	R	X – ,BN	
(E-T) My 2156-6C-1Y-2C	"	x	2 – 4 4 – 0	R	4	
(E-T) My 2156-6C-2Y-1C	"	x –	2 – 3 – 5 – 0	3 – R 2 – S	2 – 4 1 – 2 +	
(E-T) My 2156-6C-4Y-1C	"	1 +	0;	I	2 – 3 –	
E – T 704-1Y-5Y-5C-2C-1C	"	0;1	0;2	I	3;– 0;	0
(A-K) (M-S) 1088-2Y-5C-5C-1C	"	0;1	4 +	S	4 + +	
Barrigon Zamora	"	4	1 +	R	0;1	
Lerma 52	"	3–	4 +	S	4 +	
Newthatch	"	4	0	I	0;1	0;
Pelon Colorado 48	"	4 +	4 +	S	4 +	

Table 14 – continued

	P.I. or C.I.No.	Race 15B	Race 49 Seedling Stage	Race 49 Adult Stage	Race 125	Race 56 Typical
Menkemen F.R. 626	Columbia	3 !	4 +	S	4 +	
Mentana Resistente	Chile	–	2 + +	1 – R 4 – I	2 –	
Timstein x Kenya 702-3Y-2Y-1C-1Y-1C	Mexico	0;1	0	I	0;	0
RL-2265 Rd[2] (R.F. 4455) R.L.2568	Canada	–	4 +	R	3 + +	
Frondoso-Kenya C9906 3702-36-2C	Texas	0;1	2 + + CN	R	x +	
" " " " -36-1C	"	0;1	2 + CN	R	x +	
Timopheevi	11802		C	I	0;	0;
Agropyron-Triticum	U.S.A.		3 +	S	3 +	
Agropyron x Triticum R.F. 3317-2	"		3,4	S	1 – 1 + 7 – 3 +	
Agropyron x Triticum R.F. 3317-3	"	2	2 – 4 8 – 0	S	3 – 3 + 2 – 0	
Kenya 58 – Frontana R.F. 4571	Brazil		x +	2 – S 2 – R	3 – 3 + 6 – 0	
Kenya 58 – Frontana R.F. 4570	"		x +	R	2 +	
Triticum – Agropyron	U.S.A.		0;	R	0;1	
Sando #15	"		0;	R	0	
Golden – Ball – Tumillo – Mindum	12924-1C		0;	–	0;1	
Kenya 58-Newthatch II-44-28-1C	Minnesota		2 – 3 14 – 0	1 – S 4 – R	0;1	
I. F. Castelar R.F. 4588	Argentina		0;	–	0;1	
St. 464 (Durum)	191365		0.1 +			
Hope	8178	4 –	0	–	–	0;1
Timstein	12347	3 –	0;2	–	–	2 –
Mayo 52 A 2156-8C-1T-2H	Mexico	0	10 – 1+ 2 – 4	–	10 – 1 + 5 – 4	
C. T. 186 Canada		–	3 – 4 4 – 0		4 – 4 – 6 – 2 +	
Ld. 356 N. Dakota		–	1 – 3 + 10 – 0		C	
L.D. 357 N. Dakota		–	—		C	
Fn – Th. I – 46-53 Minn. 2854		–	0;		0;	
T – Hy II-44-65 Minn.		–	0;		0;	
Y – Kt 2254-8C-2Y-2C-2Y	V-42 V-52-53	0;1	1 +		1 + +	
Y – Kt 2254-8C-2Y-2C	V-70 C-52-53	0;	1 +		1 +	

REACTION OF VARIETIES AND LINES IN THE 1952 LATIN AMERICAN RUST NURSERY TO RACES 15B AND 49 OF STEM RUST IN MEXICO

John W. Gibler 1/, Aristeo Acosta 2/, and Gregorio Vazquez 2/

In the summer of 1952 as part of the cooperative program between the Oficina de Estudios Especiales, S. A. G. and the Division of Cereal Crops and Diseases of the U. S. Department of Agriculture, the 1200 entries of the Latin American Nursery were tested for their reaction to stem rust. The summer nursery was planted at Mexe, Hidalgo, where a very severe epidemic of 15B developed. Race 49 also developed late in the season and attacked a great many of the late maturing varieties and lines. However, since this race built up during the latter part of the season, it is probable that many of the early maturing varieties escaped infection.

All of the 1200 entries in the nursery were tested in the seedling stage in the greenhouse against race 49. The original inoculations with this race was made, with what later proved to be an impure collection of race 49. The inoculum for this test was obtained from a field collection from Kenya 324 (C 9906) and multiplied in the greenhouse on the same variety. All lines which were completely susceptible in the first greenhouse inoculation test were not retested. All lines or varieties that showed some degree of resistance in the preliminary test were retested against a purefied collection of race 49. The temperatures in the greenhouse during the time these tests were made varied from 65 to 85.

The results of the field and greenhouse data may be summarized as follows;

1. Bread wheats varieties which were resistant in both field and greenhouse tests:

   a) Kenya 338 AC.2E.2, Kenya B 286, Kenya 184.P.2.A.1.F., Kenya 360H.

   b) P.I.170904, P. I. 170905, P. I. 170910, P. I. 170914, P.I. 170925** (all from Transvaal Africa).

   c) P. I. 189812 and Veadeiro.

2. Parental and Commercial Bread Wheat Varieties which were resistand in Greenhouse to Race 49, but Susceptible in Field (probably field susceptibility in most cases due to race 15B).

   a) Cadet, Henry, Thatcher, Newthatch, Lee, Mida.

   b) Egypt Na 95, Kenya 338 AA.1.A.2.

   c) Mentana, Gabo, Timstein, Frontana, Rio Negro, Supremo.

   d) (Ill. 1-Chinese)^2 - Timopheevi

3. Bread Wheats Commonly used as Parents in Breeding Program for

1/ Rockefeller Foundation - Londres 45 - Mexico, D.F.
2/ Mexican Dept. Agriculture, - Officina Estudios Especiales.

Resistance to Race 15B. These varieties were susceptible in both the greenhouse and in the field. (All are resistant to race 15B).

a) Kenya 58, Kenya 117A, and Kenya C 9906 (RF 324).

b) McMurachy.

c) Egypt Na 101.

d) No 43 South Africa.

e) Lerma and some reselections of Kentana.

4. Triticum dicoccum, Triticum durum and Triticum turgidum varieties resistant in both greenhouse and field:

a) Khapli.

b) Caravaca #1.

c) Rojal de Alicante and Rojal de Almeria.

d) St. 464 Ethiopia.

e) Sernai Caieb.

f) Camadi Abdu tipo 103.

g) Amarai Blanco tipo 142.

h) C. I. 7261-15, C.I. 7501, C.I. 7859, C.I. 8131.

i) Beladi 116 P. I. 133457-2c.

f) Golden Ball-Iumillo-Mindum RL 1714.
" " " " RL 1714-1c
" " " " RL 1714-2c
" " " " RL 1714-3c

5. Crosses from different breeding programs which showed a high degree of resistance in the field (to race 15B) and in the greenhouse to race 49:

Cross	Number of lines Resistant	Country
Kentana - Yaqui	35	Mexico
Gabo - (Kenya 321-Urquiza)	5	"
(Egypt Na 101 x Timstein) x Mayo	6	"
Yaqui x (Egypt Na 101-Timstein)	10	"
Supremo x Kenya^2	3	"
Supremo^2 x Kenya	2	"
Timstein x Kenya^2	2	"
Egypt Na 101 x Timstein	3	"
Yaqui x (Timstein-Kenya)	5	"

Cross	Number of Lines Resistant	Country
(Mentana-Kenya) x Supremo	2	Mexico
Kenya x (Mentana^2-Supremo)	3	"
(Newthatch-Marroqui^2) x (Kenya 321-Urquiza)	1	"
(Mentana^2-Supremo) x (Egypt Na 101-Timstein)	1	"
Mentana x Kenya	3	"
Timstein x Kenya	1	"
(Supremo-Kenya) x (Egypt Na 101-Timstein)	1	"
Gabo x (Maria Escobar x Kenya)	1	"
Mentana x ((Newthatch-Marroqui) Maria Escobar)	1	"
(Aguilera-Kenya)(Marroqui-Supremo)) x Yaqui	4	"
Kenya$_{58}$ x (Mida-Newthatch)	5	Minnesota
Frontana x Thatcher	4	"
Kenya$_{58}$ x (Mida-Thatcher)	1	"
Frontana x II-44-22	30	"
Frontana x II-44-29	45	"
Mida x (McMurachy-Exchange)	17	"
Timstein x Mida	1	"
Mida x Kenya 117A	2	"
Kenya$_{58}$ x Newthatch	1	"
Pilot x Kenya 58	1	"
(Mida-Newthatch) x Kenya 117A	2	"
Red Egyptian x Frontana	1	"
Kenya-Gular x (Kenya 58-Newthatch)	3	"
Frontana x RL 2265-Redman^2	1	Canada
RL 2265 x Redman^3	1	"
Thatcher x RL 2265-Redman^2	1	"
Renacimiento x Kenya	6	Texas
Frondoso x Kenya	4	"
Santa Catalina x Red Egyptian	1	Chile

Many of the Mexican and Canadian wheats were severely attacked by race 49 in the greenhouse; although some lines from both programs were highly resistant. The Minnesota and Texas wheats in general, were quite resistant both in the greenhouse and field to 15B and 49. However, all the North Dakota, South Dakota, Wisconsin and Argentine wheats while quite resistant to race 49 in the greenhouse were completeley susceptible in the field to race 15B.

Because of its demonstrated virulence on many of the wheats used as parents and on the wheats in the various breeding programs, it would be advisable to test any material considered for preliminary increase to race 49 of stem rust of wheat.

Discussion:

N. E. Borlaug: About half the plants in C.T. 186 are resistant to race 49, but some are not resistant.

R. F. Peterson: C. T. 186 is a bulk of the 15B resistant lines of C. T. 181. Dr. Borlaug's results with race 49 on C. T. 186 would indicate that resistance to 15B and to race 49 are controlled by different genes.

N. E. Borlaug: If people who send material to us for testing would point out the varieties they are most interested in, we could make selections of plants showing superior types of resistance.

BREEDING WHEAT FOR RUST RESISTANCE IN COLOMBIA

J. A. Rupert

The wheat improvement program in Colombia is a joint project of the Colombian Ministry of Agriculture and the Rockefeller Foundation, initiated in June of 1950. The primary objective of the program is to develop early-maturing, spring-type wheats with rust resistance, good yield, and satisfactory milling and baking quality. Wheat is cultivated at altitudes ranging from 7000-9000 feet where temperatures of 50--65°F. prevail. Under these conditions yellow stripe rust (Puccinia glumarum) causes serious losses, generally exceeding stem rust in destructiveness. Leaf rust develops in epidemic proportions throughout most of the wheat region.

Races 48 and 15B of stem rust have been identified from Colombia by Dr. Stakman to date. Thus far no race identifications of leaf or stripe rust have been made.

Sources of Resistance

A. Stem Rust.

The following wheats, among others, are being used as sources of resistance:

Kenya C9906; RF 324	Egypt Na 101
Kenya 58	S. Africa No. 43
Kenya 117A	Egypt Na 101-Timstein (Mexico)
Kenya 338 AC.2.E.2	Egypt Na 101-Kenya C9906(Mexico)
Kenya 338 AA.1.A.2	

A number of wheats showing a high degree of field resistance during 1951 have developed susceptible type pustules in the 1952 nursery. These include McMurachy, Egypt Na 95, Red Egyptian, Kenya-Gular 5963, and Eureka.

B. Leaf Rust.

Hope and its derivatives give protection against leaf rust in Colombia. Several Brazilian and Argentine wheats are also being used:

Supremo	Klein Cometa
Lee	La Prevision 25
Rio Negro	Maria Escobar
Frontana	Barleta

C. Stripe Rust.

The outstanding sources of resistance for stripe rust are found in Italian, Brazilian, and Chilean wheats, as follows:

Italy	Brazil	Chile
Mentana	Frontana	Lincoyan
Ardito	Rio Negro	Mentafen
Riccio	Cincco	Enrique Matte
Pieve	Frocor	
Quaderna	Salles	
Balilla		

Two varieties from the hard red spring region, Lee and McMurachy, are highly resistant. A considerable number of Mentana_2--Kenya C9906 lines from Mexico combine stripe rust resistance with desirable agronomic type and 15B resistance. Three of these lines are currently being increased for early distribution.

Sources of Earliness

Because of the short day length (12 hours, plus or minus 25 minutes the year round), most wheat varieties from long day length countries, such as the United States, Canada, Russia, and Argentina, are extremely late-maturing. On the other hand, wheats from Australia, Mexico, Italy, and Brazil are generally eafly-maturing, and can be harvested during the dry season (August, September) preceding the second rainy season of the year (October-December). The best sources of earliness under short day length are derived from the following varieties:

Gabo	Frontana
Timstein	Lerma
Sunset	Yaqui 48
Frocor	Mentana

PROGRESS IN BREEDING HARD RED WINTER WHEATS FOR RESISTANCE TO RUST IN KANSAS

C. O. Johnston, E. G. Heyne, J. W. Schmidt, and W. C. Haskett

Work has been under way in Kansas for many years on the problem of breeding hard red winter wheats for combined resistance to stem rust, leaf rust, bunt, loose smut, and Hessian fly. Until recently the

stem rust resistance was derived mostly from Hope. These crosses now are in advanced generations. The remaining selections are mostly short-strawed, high tillering, high yielding, and early like Pawnee. They continue to show high resistance to stem rust in the field in the absence of race 15B. The severity of brown necrosis has been greatly reduced by selection. Some of the most promising crosses are: Mediterranean-Hope x Pawnee^2 and ^{3}, (Med.-Hope x Pawnee) x Ponca, (Comanche x Med.-Hope) x Chiefkan, (Med.-Hope-Pawnee) x (Oro-Ill. No. 1-Comanche), Timstein x Pawnee, Timstein x Comanche, and Timstein x (Mqo.-Oro x Kawvale-Tenmarq).

Intensified breeding for resistance to race 15B has been under way since 1950. Several crosses made for resistance to other races have yielded some lines with strong resistance to 15B. The best of these crosses are Oro-Med.-Hope x Kenya R.L. 1373, Kenya R.L. 1373 x Marquillo-Oro, Kenya R.L. 1373 x Hope-Turkey, Med.-Hope-Tenmarq x McMurachy, Bobin-Gaza-Bobin x Pawnee, Egypt Na. 101 x Hope-Cheyenne, and Kawvale-Marquillo-Clarkan x Red Egyptian. Only certain selections of those crosses have shown resistance to 15B. One selection of each of the first four crosses mentioned above was resistant to stem rust in Mexico where race 15B was present in abundance in 1952. Some of the best of these lines are being used as parents in further crosses. Other crosses in early generations involve Kenya 58, Kenya 117A, Kenya 338 AC.2.E.2, Kenya 1373, Kentana, Maria Escobar, and Red Egyptian in combination with various hard red winter varieties. Preliminary studies of F_3 and F_4 lines of Frontana x Med.-Hope-Pawnee have revealed the presence of some lines resistant to 15B.

Some of the most promising resistance to 15B as well as other rust races has been found in wheat x Agropyron crosses. Material involving the species _A. elongatum_, _A. trichophorum_, and _A. intermedium_ has been grown. The best stem rust resistance was obtained from _A. elongatum_ crosses. More than 3000 wheat-agropyron selections from various sources have been studied during the past 5 years. About 50 of the more resistant lines comprising wheat-like, intermediate, and grass-like types have been kept for further use. It was noted in 1952 that after a prolonged period of high temperatures in June some lines exhibited considerable stem rust although the infections were of a resistant type. The most advanced cross is (Chinese^2-_A. elongatum_) S44-2-7 x Pawnee which is in F_5. Some lines approach 42 chromosome numbers and hold their resistance under moderate temperatures. Recent studies in this cross indicate that resistance to races 15B and 56 is due to the same factor. Selections from Kharkof x _A. elongatum_ also are being used in crosses with hard red winter wheats but the progenies all are in early generations.

One of the outstanding results of breeding wheats for resistance to leaf rust in Kansas has been the production and distribution of the variety Ponca (Kawvale-Marquillo x Kawvale-Tenmarq) C.I. 12128.

This variety, approved in 1951, has the highest field resistance to leaf rust of any variety ever distributed in Kansas.

Most of the crosses with Hope in their parentage, discussed under stem rust above, also have strong resistance to leaf rust. During recent years Hope hybrids appear to have lost some of their resistance to leaf rust, due to shifts in predominance of physiologic races, especially in the spring wheat region. This has not been so marked in the hard red winter wheat area although there has been some reduction in the resistance of Hope hybrids. This has brought about a change in the parental material used as the source of resistance to leaf rust. Most of the rust resistant parents used in recent years have come from South America because wheats from that area have a broader base of resistance to physiologic races than varieties from elsewhere. The following list gives most of the South American wheats that have been used as parents in crosses with hard red winter wheats:

Variety	Number	Source
Sinvalocho	C.I. 12595	Argentina
* La Prevision 25	C.I. 12596	"
*Aniversario	C.I. 12578	"
*Titan		"
Centenario	C.I. 12021	"
Benvenuto Inca	C.I. 12588	"
Frondoso	C.I. 12078	Brazil
Frontana	C.I. 12470	"
Surpresa	P.I. 106505	"
Rio Negro	C.I. 12469	"
*Renacimiento	C.I. 12021	Uruguay
Maria Escobar	P.I. 150604	Peru

* Resistant to all races with which tested.

In addition to these, many crosses have been made with Timstein and with various selections and backcrosses of McMurachy-Exchange x Redman from Canada. Crosses involving both courses of resistance have yielded many lines with excellent leaf rust resistance. The most promising material in advanced generation crosses seems to be in the crosses Frontana x Med.-Hope-Pawnee and Frontana x Marquillo-Oro. Some selections of Sinvalocho x Pawnee$^{2\ \&\ 3}$ also are promising. Many of the wheat x Agropyron lines have high resistance to leaf rust as well as stem rust. A few crosses also have been made using Gabo P.I. 155431, Warden C.I. 4994, and Exchange R.L. 1803 as sources of resistance. The last two varieties did not yield much of value in combination with hard red winter varieties.
(Bureau of Plant Industry, Soils and Agricultural Engineering, U.S. Department of Agriculture, and Departments of Botany & Plant Pathology, and Agronomy, Kansas State College, Manhattan, Kansas cooperating).

BREEDING FOR RUST RESISTANCE IN SOFT RED WINTER WHEATS

Ralph M. Caldwell, L.E.Compton, John F. Schafer, and Fred L. Patterson

The Purdue program of breeding for disease resistance in soft winter wheats was begun in 1918 in cooperation with the United States Bureau of Plant Industry.

Leaf Rust Resistance

Both the seedling type and mature plant type of resistance are currently being utilized. Resistance from a number of different sources appears promising at present but cannot be considered adequately tested until grown on considerable acreage. In the light of past experience, any single source that holds up against all races for a period of time when widely grown will, indeed, be exceptional.

Mature plant resistance from <u>Chinese C.I. 6223</u>: This resistance, which is strictly a mature plant type, has been brought along in the Purdue program since 1925. A number of especially early, short, high yielding lines which are particularly adapted to southern Indiana have more recently been produced. One of these is now being increased for prospective distribution. This resistance has been excellent wherever observed by the writers, but there are several records of its having had a high infection of a resistant type.

Mature plant resistance from <u>Frondoso</u> and <u>Surpresa</u>: Resistance which is very similar in type to that of Chinese has been transferred from these Brazilian wheats to a number of promising high yielding, soft winter lines. No significant leaf rust infection has been observed on these since this resistance was introduced into crosses in 1939. This material carries limited seedling type resistance as well as the broad mature plant resistance.

Combination mature plant and seedling resistance from composite crosses: The parents Wabash, other resistant Fultz selections, Hope-Hussar, and Hungarian have been widely used in a variety of combinations with other parents in this program. Many lines showing varying degrees of resistance including a number with high resistance have been selected from such crosses. Notable among these are selections of:

- 39141 = Fairfield x Trumbull^2, Hope, Hussar
- 442 = Trumbull^3, Hope, Hussar, Thatcher x Trumbull, Hope, Hussar, Fulhio, Purkof
- 4417 = Trumbull, Hope, Hussar, Fulhio, Purkof x Trumbull, W38, Fultz, Hungarian
- 4126 = Kawvale, Fultz, Hungarian, W38, Wabash, Fairfield Trumbull^3 Hope, Hussar.
- 40149 - Fultz, Hungarian, W38, Wabash x Fairfield, Trumbull, Hope, Hussar

Seedling resistance from 3369-61-1: This group of related lines from the cross Wabash x American Banner was found to be resistant in

the seedling state to all races tested at Lafayette, Manhattan, St. Paul, and Winnipeg, prior to 1950. This resistance far exceeds any expectation from the parentage. In 1950 an isolated collection of leaf rust was obtained in Indiana which produces a completely susceptible seedling reaction on this material. However, it appears to have considerable mature plant resistance to this race. This resistance is evidently rather complex genetically. These lines have excellent agronomic type and performance records and have been extensively used in further crossing.

Seedling resistance from *Warden C.I. 4994:* Warden x Leap C.I. 12660, a soft, red winter derivative, has been used considerably, and Exchange (Warden x Hybrid English), a spring, and some of Dr. R. F. Peterson's further derivatives from it have been used to a lesser extent. Exchange has seedling resistance to all races to which tested, and C.I. 12660 to all except race 43 in tests at St.Paul and to new collections of race 104 or 30 at Lafayette in 1951 and 1952. C.I. 12660 is resistant to the new collection attacking the 3369 resistance and vice versa. Derivatives of the two are now under test to both collections.

Seedling resistance from *Aniversario C.I. 12578:* This resistance was brought into the breeding material in 1948 and derivatives are now under preliminary study. So far it has been difficult to obtain satisfactory soft types.

Seedling resistance from *Agropyron elongatum:* A number of wheat-like derivatives of *A. elongatum* x *T. vulgare*^{2} are immune in the seedling stage to the leaf rust races tested and are now being used extensively in further crossing.

Limited seedling resistance from *Malakof:* The dominant monofactorial resistance of Malakof to races 15, 76, and others is being brought into Vigo by the back cross method as race 76 has so far been the most serious on Vigo in Indiana.

Stem Rust Resistance

The stem rust resistance from Hope-Hussar and from Frondoso and Surpresa have been brought along in this program for a number of years. Several promising lines carrying these singly or in combination are now in the later phases of testing. This material has continued to look satisfactory in the field but is in need of evaluation with the current races.

Seedling resistance from *Red Egyptian C.I. 12345:* This resistance was brought into crosses in 1945. This material looks to be especially promising in that it has had high field resistance, has shown seedling resistance to race 15B, and had high resistance in Mexican tests by Dr. B. B. Bayles.

Seedling resistance from Agropyron elongatum: This resistance has been derived in the same breeding stock with the leaf rust resistance from this same source. It appears promising and is now being used extensively in further crossing.

Resistance from Kenya types: Crosses with Kenya R.L. 1373 were first made in 1940. More recently Kenya K58 and Kenya 338 have been used. This material has not been thoroughly evaluated in connection with current races.

Resistance from Triticum timopheevi: Breeding material carrying this resistance has been obtained from Dr. R. G. Shands and has recently been brought into crosses in this program.

Resistance from McMurachy: Derivatives from Dr. R. F. Peterson's McMurachy, Exchange x Redman crosses have also recently been brought into crosses in this program.

SPRING WHEAT FOR COMMERCIAL USE IN NEBRASKA AND FOR BREEDING IMPROVED VARIETIES OF HARD RED WINTER WHEAT.

L. P. Reitz and V. A. Johnson

Spring wheat is of commercial importance in western Nebraska where in the last decade about 80,000 acres annually have been grown from which approximately 900,000 bushels of grain per year have been harvested. Therefore, rust resistant varieties to replace Mida, Thatcher and Rushmore (currently recommended) are sought. Nebraska does not have a spring wheat breeding program, but tests annually those varieties included in the regional programs, numerous foreign introductions, and local varieties from many sources. The number varies from year to year. In 1952 there were 139 varieties evaluated at Lincoln, whereas for 1953 over 1,200 are to be observed which will consist largely of the durum collection maintained by the U. S. Department of Agriculture.

Recommendations to farmers are based almost entirely on adaptation tests conducted at the Box Butte Experiment Farm near Alliance since this station is most representative of the spring wheat area of the state. Satisfactory yields and good weights per bushel were recorded for a few spring wheats with high resistance to leaf and stem rust at Alliance in 1952. Some of these were the following: Timstein x Mida (C.I. 13027), Rushmore x Surpresa (C.I. 12972 and 12973), McMurachy-Exchange-Redman (C.I. 12953) and Thatcher x Surpresa (C.I. 12641). These yielded slightly more grain per acre than Thatcher and were heavier per bushel except in the case of C.I. 12953. Three Frontana x Thatcher selections had good rust readings, yielded more than Marquis, but were slightly less productive than Thatcher. Three to five years of data are ordinarily required before relative productivity can be established.

Spring wheats have been used extensively in breeding improved hard winter varieties for Nebraska. Hope H-44, Timopheevi, and Marquillo have appeared in many hybrids in an effort to transmit disease or

insect resistance to Nebraska wheats. For the most part, resistant selections and backcrosses have not possessed sufficient drought resistance or winterhardiness.

Since stem rust race 15B came on the scene, many more spring varieties have been used as breeding stock. The accompanying table lists some of the best sources of resistance based on field reaction in the presence of races 15B, 56, and perhaps others. Crosses and backcrosses with winter wheat have been made with most of the varieties listed. Segregates are being screened in the winter 1952-53 in greenhouse tests, and such information will be used in deciding which lines to perpetuate among the field plantings established in September 1952.

Apparent semi-lethal physiologic incompatability of certain of the Kenya derivatives crossed with winter wheats has been observed in the greenhouse this year. This condition has been noted in the F_1's of 15B resistant F_2 segregates of Mida-Kenya 117A x Hope-Turkey^2, Mida-Kenya 117A x Cheyenne Sel.-1279A9^{III}16, and Kenya-Mentana x Cheyenne Sel.-1279A9^{III}16 backcrossed to the winter parents. It is characterized by marked chlorotic stipling of the seedling leaves, particularly in the central portion of the blade, followed by necrosis which progresses toward the base and tip, culminating in the death of the entire leaf. The severity and incidence of the condition appears to be variable depending upon the cross. In Mida-Kenya 117A x Hope-Turkey-Turkey^2 and Mida-Kenya 117A x Cheyenne Sel.-1279A9^{III}16^2 most plants show severe symptoms, while in Kenya-Mentana x Cheyenne Sel.-1279AIII16^2 occasional plants are affected mildly. The condition was not observed in the original F_1 seedlings which after a period of vernalization in late winter were transplanted into the field. This suggests that the deterioration observed this winter may be associated with greenhouse conditions. The F_1's of several crosses involving the above spring parents and other winter wheats show no symptoms.

Several sources of 15B resistance in winter wheat are also being utilized in the breeding program at Nebraska. These include Wisconsin's timopheevi-vulgare 475 x Cheyenne, McMurachy-Exchange-Redman^3 x Cheyenne, Marquillo-Oro-Pawnee x Frontana, Oro-Mediterranean-Hope x Kenya, and Mediterranean-Hope-Tenmarq x Kenya. In Mexico in 1952 these wheats exhibited resistance to 15B and other stem rust races prevalent there. The selections of winter types from timopheevi-vulgare 473 x Cheyenne and Marquillo-Oro-Pawnee x Frontana were made in Nebraska while the others originated in Kansas followed by reselection in Nebraska.

The difficulties encountered from the use of spring wheat in a winter wheat breeding program need to be emphasized. These include the introduction of non-hardy and drought-susceptible germ plasm, substandard grain quality and agronomic characters, and possible susceptibilities to currently minor or unknown diseases and insects in addition to detrimental unforseeable interactions. It has been the experience of several breeders that the recovery from spring x winter crosses of the level and type of winter hardiness and drought resistance necessary in the winter wheats is more difficult than first be-

lieved. The ability to withstand low temperatures as well as large fluctuations of temperature is extremely important. Tests need to be made of the cold hardiness of winter types from spring x winter crosses as the plants pass from dormancy to active growth in the spring. A loss in this aspect of hardiness probably would be as serious as a loss of midwinter cold tolerance.

Rust readings on some breeding stocks. Spring wheat observation nurseries at Lincoln and Alliance, 1952.

	Sel.	Field readings at Lincoln			Alliance	
	or	L.Rust	S.Rust	S.Rust	L.Rust	S.R.
Strain	C.I.No.	6/24	7/2	response	7/12	7/14
		%	%		%	%
Marquis (check)	3641	65	65	C.S.	80	23
Frontana	12470	0	5	R.	--	--
Frontana x (2265 x Redman)^2	12919	0	10	S.	--	--
Rio Negro	12469	0	35	R.	--	--
Webster	3780	3	5	R.	--	--
Kenya 58	12471	50	2	R.	--	--
Kenya 117A	12568	55	T	H.R.	--	--
Kenya 338 A.C. 2E2	12880	0	T	H.R.	--	--
Kenya 338 A.A. 1A2	P.I.177180	T	T	H.R.	--	--
Mida x Kenya 117A	12916	30	T	H.R.	--	--
Mida x Kenya 117A	II-44-2	40	T	H.R.	--	--
Kenya 58 x Newthatch	13032	30	T	H.R.	40	0
Kenya 58 x Newthatch	12961	45	5	R.	85	T
Kenya 58 x Newthatch	II-44-26	40	2	R.	--	--
Maria Escobar x Newthatch -Peru	12888	5	15	R.	--	--
Newthatch-Marroqui x Supremo-Peru^2	12891	T	2	H.R.	--	--
Red Egyptian	12345	20	10	R.	--	--
Egyptian Na 95	12894	45	15	R.	--	--
Red Egyptian x Frontana	II-45-6	15	T	R.	--	--
Ill. x #1-Chinese^2 x Timopheevi	12633	0	T	H.R.	--	--
McMurachy-Exchange x Redman	P.I.187166	0	T	H.R.	0	0
47-68/H 1151	Sel.137	T	5	R.	20	5
Mida (check)	12008	65	75	C.S.	35	25
Mindum (durum)	5296	2	25	C.S.	0	20

PROGRESS IN BREEDING LEAF AND STEM RUST RESISTANT WINTER WHEAT VARIETIES FOR TEXAS CONDITIONS

I. M. Atkins and E. S. McFadden

Breeding for resistance to leaf and stem rust is carried on at two locations in Texas, namely, College Station and Denton. Up to the present time, there have been no facilities or personnel available for fundamental studies or tests with specific races. Tests of the reaction of varieties have been carried out in the field under natural epidemics of the organisms, although often epidemics have been started in spreader rows with known

races. Environmental conditions are ideal for the development of natural epidemics of both rusts at College Station. Environmental conditions are usually favorable for leaf rust epidemics at Denton, in North Central Texas, but stem rust epidemics occur less frequently.

Early breeding work at both stations utilized Hope and certain other parents as sources of resistance. This work culminated in the distribution of Austin (Mediterranean x Hope) and Seabreeze (Mediterranean-Hope x Gasta), soft, red winter wheats in the early 40's and more recently in the distribution of Quanah [(Mediterranean-Hope x Comanche F_1) x Honor-Forward x Comanche F_1)] , a high quality, hard, red winter wheat. Westar (Kanred-Hard Federation x Tenmarq), resistant to the races of leaf rust prevalent until recently, was distributed in 1944 and has become a major variety in the hard winter wheat area of Texas. More recently, Supremo (Surpresa x Mediterranean-Hope) was developed in our program and released in Mexico by the Rockefeller Foundation, but was not officially released in Texas.

Many additional strains from this earlier breeding work are still in various stages of testing in the Texas small grain improvement program, and a few are included in regional tests. Three strains are being increased in 1953 for final quality tests before their release to growers. These are Fronteira x Red May^2 131-46-3, a soft red winter wheat adapted to North Central Texas; and, two hard red winter wheat strains, Sinvalocho x Wichita) x Hope-Cheyenne) x Witchita, C.I. 11702 and 11703. All three strains have high resistance to present prevalent races of leaf rust and to the common races of stem rust, but they are not resistant to race 15B. Several crosses were made with Kenya strains in this earlier breeding program, but none proved resistant to race 15B. Two crosses, Comanche x Red Egyptian and Clarkan x Red Egyptian, now in advanced generations, offer some promise as sources of strains resistant to 15B. These crosses are now being explored.

At College Station, a definite program to combine the mature plant type of resistance from McMurachy and Kenya wheats was started in 1939. None of the resulting selections was sufficiently resistant to leaf rust for southern Texas conditions. In 1941, the program was expanded in a planned attempt to combine the Kenya resistance to stem rust with the high type of resistance to leaf rust found in the South American varieties, Renacimiento, Triunfo, Frondoso, Fronteira and Surpresa. These crosses between the Kenya and South American wheats have given the most promising selections for south Texas conditions that have been developed to date. The Renacimiento x Kenya and Surpresa x Kenya crosses have been the most thoroughly explored. Two selections from Renacimiento x Kenya, C.10862 are now being increased for release. These are Selection 32 which is being increased to replace Austin and Supremo in South Central Texas, and Selection 131 which will replace Seabreeze in extreme southern Texas. Both of these selections are resistant to the virulent stem rust Races 11 and 15B, and also to the present prevalent races of leaf rust. These two new wheats, together with Goliad barley recently released for growing in South Texas, will provide adapted varieties of wheat and barley which are resistant to race 15B. The growing of these resistant varieties in South Texas

should aid in the reduction of overwintering and early spread of rust.

In North Texas, the area served by the Denton Substation and a much more important commercial wheat growing area than South Texas, the rapid increase of races of leaf rust which attack Hope derivatives, as well as important commerical varieties, such as Westar, Pawnee and Comanche, made necessary new breeding work in recent years. New crosses were made in 1948 to combine the best known leaf rust resistance with adapted commercial varieties. These crosses are now in the fourth generation. Only a few involve parents which have resistance to race 15B of stem rust. A list of these crosses follows:

Resistant Parent	Rust susceptible parents used in crosses
Fronteira	Quanah, Wichita, Fultz
Exchange	Quanah, Wichita, Kiowa
Timstein-Newthatch C.I. 12641	Comanche, Martin-Tenmarq-Sel.
Lee	Triumph, Red May
Rio Negro	Kharkof
Frontana	Fultz
Waldron's vulgare derivative of (T. tim. x Ae.sq. Amphidiploid)	Westar, Wichita, Triumph, Red May

With the rapid increase in importance of race 15B of stem rust, many new crosses were made to add resistance to this race to the best commercial varieties and new strains developed in the earlier breeding program. These new combinations are now in the second generation. Some of the new combinations are listed below:

Resistant Parent	Rust susceptible parents used in crosses
Renacimiento x Kenya-Gular Sel.22	Fultz, Denton, Comanche, Red May
T.tim. x Ae.speltoides) x Austin^2	Tenmarq, Vigo, Denton
T.tim. x Ae.speltoides, Amph.	Mediterranean, Triumph, Cimmaron, Sinv. x Wich.) x Ho-Chey) x Wichita
McMur.-Exchange-Redman, R.L. 2325	Comanche x Bkl-Hd.Fed., C.I. 12517
Frontana x (2265 x Redm^2) R.L. 2520	Quanah, Comanche x Bkl-Hd.Fed., Sinv. x Wich.) x Ho-Chey) x Wichita
Chinese x Agr-Elongatum, S 44-2-7	Quanah
Kenya 117A	Triumph, Sinv. x Wich.) x Ho-Chey) x Wich.
Egypt Na 101 x Hope-Cheyenne, 1476-8	Comanche
Frontana	Fultz, Comanche, Westar
Sinv. x H44-Bose, Agr. G-1-3-3-1	Fultz, Triumph, Quanah, Comanche
Ill. 1-Chinese-T. tim, Wis.245	Thorne

In South Central Texas, northwest of the City of San Antonio, there is an acreage of durum wheats grown for livestock feed and winter pasture. Durum wheats in this area were injured by race 15B in 1952. This area may be an important factor in early season spread of race 15B. The North Dakota Station has kindly supplied us with seed of the 15B

resistant durums, C.I. 3255 and P.I. 94701 which are now being tested. Owing to the fact that the durums are grown only for livestock feed in this area, quality will not need to be considered in the release of new strains. Several crosses have been made between commercial durum varieties and strains resistant to race 15B. The common wheat, Egypt Na 101 x Cheyenne 1476-8 appeared promising at this location in 1952 and has been placed in replicated tests this fall.

Dr. M. C. Futrell, Pathologist, has recently been stationed at College Station. An Agronomist will be stationed at Denton in the near future. This expansion is made possible with funds provided by the Division of Cereal Crops and Diseases, U. S. Department of Agriculture. An expansion of both fundamental studies and breeding work is planned.

PROGRESS IN BREEDING FOR LEAF RUST RESISTANCE WITH AGROPYRON-WHEAT HYBRIDS

A.M. Schlehuber and Harry C. Young, Jr.

Because of the importance of leaf rust in Oklahoma and surrounding areas, a search was made for various sources of resistance. In the spring of 1947, fifteen strains involving _A. elongatum_ parentage were received from the Kansas Station. Two of these were crossed with locally adapted wheats. However, only crosses with one of the two have been continued. This strain, _Triticum_ sp. - _A. elongatum_ Ks. 464708, has shown a resistant response (either 2R or 0;) to individual leaf rust races in the seedling stage (see table) and an immune or highly resistant response in the mature plant stage (see table 15).

F_1 through F_4 generations of _Triticum_ sp. - _A. elongatum_ x Pawnee have been tested. Wheat-like, leaf-rust immune F_4 lines with fair to good test weights have been obtained. Preliminary milling and baking data indicate high protein content, fair to questionable to unsatisfactory flour yield, and fair to poor to very poor evaluations of dough mixing properties. An attempt will be made to correct these deficiencies by crossing some of the better lines with "strong" flour wheats such as Comanche and Ponca.

Table 15. Seedling reaction of _Triticum_ x _Agropyron elongatum_ (Stw. '493959 from Ks. 464708) individual leaf rust races. Stillwater, Oklahoma, 1950-51*

	Leaf Rust Race						
	5	9	15	21	58	105	126
Reaction	2R	0;	0;	0;	0;	0;	0;

* Greenhouse seedling leaf rust reactions determined by H. C. Young, Jr. and D. F. Wadsworth, Plant Pathology Department, Oklahoma A. & M. College.

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Field reactions to leaf rust of the Triticum x A. elongatum and Pawnee parents, the F_1, and the F_2.
Stillwater, Oklahoma, 1950.

Parent or Cross		No.plants resistant	No.plants susceptible	Total
Triticum - A. elongatum (P)		100*	0	100
Pawnee (P)		0	55	55
F_1	1949	6	0	6
	1950	5	0	5
F_2	'48 x 15-1	19	33	52
	'48 x 15-2	201	161	362
	'48 x 15-3	179	146	325
	'48 x 15-4	57	118	175
	'48 x 15-5	102	91	193
	'48 x 15-6	176	143	319
Total F_2		734	692	1,426

* Approximate number, no actual plant counts.

Tuesday afternoon, January 6.

BREEDING FOR LEAF RUST RESISTANCE IN WINTER WHEATS IN SOUTHERN ALBERTA

J. E. Andrews

In Southern Alberta wheat stem rust (Puccinia graminis tritici) seldom causes material damage. Leaf rust (P. triticina) is more widespread and occasionally causes losses of economic importance particularly on irrigated land. In the present winter wheat breeding program at Lethbridge stem rust resistance is considered as a desirable but not essential character in new varieties; leaf rust resistance is more important particularly in varieties intended for irrigated land.

Surveys of physiologic races of cereal rusts in Canada have indicated that the distribution of races of both stem and leaf rust of wheat in Southern Alberta differs from that in the other prairie provinces, but resembles that in the Creston area of south-eastern British Columbia. There is a suggestion that spore dispersal may take place across the mountains in this area. In view of the similarity of race distribution and since, at Lethbridge, the establishment of a rust nursery is unreliable, our breeding material is tested for leaf rust reaction at Creston, B.C. where a natural epidemic usually can be depended upon.

The selection Purdue 3369-61-1-4-1-2-2-1 of Wabash x American Banner has been highly resistant in the field at Creston, B.C. and is being used as a source of resistance in the breeding program. Several T. vulgare x Agropyron elongatum derived lines obtained from L. H. Shebeski have also show high resistance. Hybrid populations of these crosses with winter wheats are being studied but appear to be lacking in winter-hardiness. Blackhawk and some winter wheat derivatives of

H-44 have been used in crosses but several of the more prevalent races of this area are virulent to these H-44 derivatives.

In our present breeding plans major emphasis is being placed on such characters as winter hardiness, sawfly resistance and bunt resistance, which are of far greater importance than rust in this region. Attempts will be made to incorporate rust resistance into hybrids at the same time. However, hybrids which lack rust resistance will not be condemmed since this character may be added later by backcrossing.

BREEDING DURUM WHEATS FOR STEM RUST RESISTANCE

R. M. Heermann

The sources of resistance used in the durum wheat breeding project during the past two years are C.I. 3255, P.I. 94701, and Khapli derivatives. The first two are durum introductions from Tunis and Palestine, respectively, and are amber durums with a moderate degree of resistance to stem rust race 15B. The Khapli emmer resistance is a more desirable type of resistance and is being brought into the crosses through two selections, Ld.271 x Khapli and Ld. 194 x Khapli. Neither of these selections are fully as resistant as Khapli emmer nor are the two of them alike in seedling reaction. These two selections were crossed in 1947 and from this cross segregates were obtained which approach very nearly the resistance found in the original Khapli parent. Selections from crosses involving the above mentioned segregates as parents are showing the most promise for resistance to 15B.

The segregating populations being studied at the present are from crosses made during the fall and winter of 1950 and 1951. From F_5 plant rows grown at Langdon in 1952, thirty-two selections were sent to Brawley, California last fall for a winter increase. The first quality and yield tests on these selections will be made next year.

Attention has been given to a stop gap variety to alleviate the severe threat to durum production caused by the appearance of race 15B. Ld. 356, a selection from the cross Ld. 308 x Nugget, shows promise of being able to serve such a purpose and is being increased at the present time. It has a very desirable combination of yield, type, and quality plus some tolerance to stem rust.

A search for new sources of resistance in durums was begun in 1951 by growing the world collection at Langdon. Under the moderate natural field infection of that year, all but 280 varieties of the original 2281 were susceptible and were eliminated. This group of 280 varieties was grown in rust nurseries at St.Paul, Winnipeg, Langdon, and Fargo in 1952. Seedling reactions were determined, using composites of 15B isolates at Winnipeg and Fargo. Data on 75 of the varieties showing resistance in the 1952 tests are given in the accompanying tables. Some of the introductions from Abyssinia appear to be the most resistant to race 15B among the varieties of this group. A number of Mexican introductions show good resistance in the adult stage in the field but have a susceptible seedling reaction.

Table 16. Durum wheat varieties from the World Collection showing resistance to stem rust in cooperative tests in 1952 by R. M. Heermann and E. A. Schwinghamer

Location – Winnipeg, Manitoba, Canada
St. Paul, Minnesota
Fargo and Langdon, North Dakota

Cooperators – A. B. Masson, T. Johnson, E. R. Ausemus
D. Sunderman, E. C. Stakman, E. Hayden
R. M. Heermann, E. A. Schwinghamer

Variety	Origin	C.I. or P.I. No.	Seedling Tests		Field Reaction			
			Fargo	Winnipeg	Fargo	Langdon	St.Paul	Winnipeg
	Tunis	3201	3–	2	30R	25R	–	5–20R
	Tunis	3255	3–	2+	10R	r10R	60S	5R–S
Media	Africa	5057	2,3–	2,3–	5R	40SR	60SR–S	Tr S, 40R
Tremez Proto	Portugal	7065	3±	3,4	5–70S	20= 30SR 80= 40S	40SR–S	Seg. Tr–70
Tremez Rijo	Portugal	7066	3±CN	3=	10R	30= 30SR 70= 40S	60SR–S	Seg.Tr–50
Tremez Molle	Portugal	7067	3–,4–	3–	5R	30= 30SR 50= 40S	30SR–S	Tr–80
	Egypt	7265-1	3±	3	5R	40SR	50S	TrS, 25R
	Egypt	7265-3	3	3+	5R–20S	40SR	20SR	TrS,20R
	Egypt	7265-5	4–	3–	TR	15R	30SR	TrS,5R
	Egypt	7265-7	4–	3+	10R	40SR	15SR	TrS,10R
	Egypt	7501	1–	1–	5R	10R	30SR	10R
	Egypt	7503	3	3+?	5R	30SR	30SR	10R
	Egypt	7505	2,4	X?	30S	30SR	15SR	5–20R
	Egypt	7506	1–,1	2	5R	50SR	60S	30R
	Egypt	7508	0;1–	1	5R	10R	60S	Tr R
	Egypt	7512	1–,3+	2–, 3+	10R	30SR	40SR	Tr S, 10R
	Egypt	7513	1–	1	5R	10R	50S	Tr R
	Egypt	7515	1	1+	5R	20R	50S	10R
	Egypt	7516	1	1+	5R	15R	60S	5R
	Egypt	7525	3,4	1,X–	5R	5R	20SR	Tr R
	Egypt	7526	3–,3	1,X–	5R	5R	45SR	Tr R
	Egypt	7527	3,4	2,X	10R	15SR	50SR	Tr S, 5R
	Abyssinia	7771	1–	1	5R	15R	30SR	T–20R
	Abyssinia	7773	1–	2–	5R	15R	60S	Tr R
	Abyssinia	7780	0;1–	1	TR	5R	50SR	0
	Abyssinia	7786	1–	2–	5R	5R	20SR	Tr R
	Abyssinia	7789	4	X	10R	30S	30SR	Tr S, Tr R
	Abyssinia	7792	1–,X	1+,X	5R	15R–SR	30SR	Tr S, Tr R

Table16-continued

Variety	Origin	C.I. or P.I. No.	Seedling tests Fargo	Seedling tests Winnipeg	Field Reaction Fargo	Field Reaction Langdon	Field Reaction St.Paul	Field Reaction Winnipeg
	Abyssinia	7794	1=,1-	1	10R	10R	30SR	Tr
	Abyssinia	7800	1=,1	1	5R	5R	20SR	0
	Abyssinia	7805	0;1-	1	0	5R	15SR	0
	Abyssinia	7806	1=	1	TR	5R	20SR	Tr - 10R
	Abyssinia	7807	1-	1	10R	15R	50SR-S	10R
	Abyssinia	7808	1-	1	5R	15R	50SR-S	5R
	Abyssinia	7809	0;1-	1	TR	15R	50SR-S	Tr-R, 0
	Abyssinia	7812	1-	1	5R	15R	50SR-S	5R
	Abyssinia	7813	1+	1	10R	25R	50SR-S	15R
	Abyssinia	7833	1=	1	10R	15R	50SR-S	Tr R
	Abyssinia	7841	1-	1	5R	10R	50SR-S	20R
	Abyssinia	7845	3=	2-	10R	30SR	20SR	20R
	Abyssinia	7858	1-	1	5R	TR	5R	0
	Abyssinia	7859	1	1	TR	15R-SR	15SR	Tr S, Tr R
	Abyssinia	7864	0;1-	1+	10R	10R	30SR	10R
	Abyssinia	7871	0;1-	1	5R	10R	10R	Tr R
	Abyssinia	7874	1-,1	1	TR	5R	30SR	Tr R
	Abyssinia	7876	0;1-	1	TR	10R	10R	0
	Abyssinia	7881	1-	1+	10R	15R	50SR	5R
	Abyssinia	7946	1-	1	10R	20R	30S	5R
	Abyssinia	8133	1-	1	TR	5R	20SR	0
	Abyssinia	8150	1-	1	5R	5R	20SR	Tr R
	Abyssinia	8154	0,1-,3	1	5R	5R	20SR	Tr R
	Abyssinia	8155	1-	1	0	TR	10SR	0
	Abyssinia	8650	1-	1	TR	25R	10SR	0
		P.I.No.						
	Palestine	94701	3-	3-,4	5R	15R	10SR	Tr R
	Brtugal	134908	X,3-	2,3-	5R	20R-SR	10S	5R
	Portugal	134930	3=	3-	10R	25SR	30SR-S	Tr S, 30R
Khapli	-		0;1=	1-	TR	TR	30S	Tr R
	Mexico	168907	3-	3=	5R	30SR	30SR	5R
	Mexico	168909	3-	3=	2R	25R-SR	50SR	10R
	Mexico	168911	3-	3=	5R	30R-SR	30SR	10R
	Mexico	168912	3-	3=	TR	25R	30SR	2R
	Mexico	168913	3-	3=	TR	35SR	40SR	5R
	Mexico	168914	3-	3-	5R	30SR	10SR	Tr R

Table 16 continued

Variety	Origin	C.I. or P.I. No.	Seedling tests		Field reaction			
			Fargo	Winnipeg	Fargo	Langdon	St.Paul	Winnipeg
	Mexico	168915	3=	3=	TR	20R	20SR	Tr R
	Mexico	168916	3=	3=	5R	20R-SR	10SR-S	Tr R
	Mexico	168917	3=	3=	5R	30SR	30SR	Tr R
	Mexico	168918	3=	3=	5R	25SR	20SR	Tr - 5R
	Mexico	168919	2,3=	2	5R	10R	20SR	Tr S, Tr R
	Mexico	168921	1+	2	TR	15R-SR	10SR-S	Tr R
	Mexico	168924	1∓,3	2+	5R	30SR	20SR	Tr S, 10 R
	Mexico	168925	3≡	3=	5R	25SR	15SR	Tr S, Tr R
	Mexico	168926	3=,4-	3=,4	20R	10R, 40S	20SR-S	20S
	France	174668	3=	3=	5R	15R	10R-SR	?
	Mexico	168705	3-	3-	5R	30SR	40S	Tr S, Tr R
	Mexico	168906	3-	3-	10R	30SR	10SR	Tr R
Stewart (ck)			4	4	60S	70S	60S	90S

Discussion:

A. M. Schlehuber: Have you tested the durum variety Dickinson? What is its leaf rust and stem rust infection?

R. M. Heermann: We have tested it, but I do not have the data with me. I think it is moderately susceptible.

P. J. Olson: Rust infections were higher at Langdon than at Fargo. Are conditions more favorable for infection at Langdon?

R. M. Heermann: Yes.

PROGRESS REPORT ON BREEDING DURUM WHEAT FOR RESISTANCE TO RACE 15B OF STEM RUST

A. B. Mason

The results of the 1952 field tests indicate that a number of good-yielding, early-maturing, short, strong-strawed durum wheats of good quality will be available for advanced testing. Unfortunately, these strains do not have resistance to race 15B, but may be of value in areas where stem rust is not a major factor.

Breeding for 15B resistance was started in 1950 and a strain from the cross Golden Ball x (Iumillo-Mindum R.L. 1317), R. L. 1714 was available as a source of resistance. The 1952 field epidemic at Winnipeg indicated that this resistance might be satisfactory to serve as a stop-gap. However, a culture of race 15B has been found to which Golden Ball is at least moderately susceptible. Strains carrying the Golden Ball resistance will be advanced to the Co-operative Test in 1953. A few of the more promising crosses involving other sources of resistance are as follows:

Cross		Generation
Chapinge R. L. 1626	x Nugget^2	C-51-F_3
"	x Carleton	"
"	x Ld. 308	C-51-F_2
"	x Stewart	"
C.I. 3255, R.L. 3171	x Ld. 308	C-51-F_3
P.I. 94701, R.L. 3170	x Nugget	"
Beloturka, R.L. 1412	x Nugget	"
"	x Ld. 308	C-51-F_2

The adult plant reactions of 14 varieties were tested in the greenhouse to two cultures of race 15B. The results are given in Table 17 .

Table 17. Adult Plant Reactions to Two Cultures of Race 15B

		Culture Number							
		50-L-65				32-51			
		Stem		Leaves		Stem		Leaves	
Variety	R.L.No.	Type	%	Type	%	Type	%	Type	%
Chapinge	1626	;1	5	;1	10	1,2	5	1	10
Gaza	1664	2,3-	30	1,2	25	2,3	40	1,2	35
G. Ball x 1317	1714.1	;1	tr+	;1+	5	X+	20	1,2+	20
" "	1714.2	;1	1	;1	5	X-	5	1,2	10
P.I. 94701	3170	;1-	tr	;1	5	;2	1	;1	5
C.I. 3255	3171	;1-	tr	;1	2	;1-	tr	;1	5
Beloturka	1412	;1-	tr	;1	5	;1-	tr	;1+	5
Mindum x McMur.	1739	;1+	tr+	;1-	tr	;1	tr	;1	tr
Golden Ball	1250	;2	3	1,2	10	3,4	20	2	25
Tremes Preto	3111	X-	10	1,2+	15	X	20	1,2+	30
Iumillo	7	;2	tr	;1	tr	X-	5	;1	1
Chapinge x 1317	1729	;1-	tr	;1	5	;2	3	X-	10
Stewart 221	1745	4	20	X+	25	4	45	X+	30
Carleton	1663	4	30	X	30	4-	30	X	30

Rust readings by T. Johnson

An attempt is being made to transfer the McMurachy resistance to the durum wheats. A number of Abyssinian strains from the world collection gave 0 readings in the field in 1952, and some of these will be used in future crosses.

Mindum x McMurachy is not a real durum wheat, although it looks like durum.

Discussion:

J. W. Gibler: The cross Golden Ball x Mindum is one of the best resistant wheats in Mexico. How does it react in Canada?

A. B. Masson: Rust readings are "Trace to Susceptible". It has very poor quality, with the same straw strength as Stewart.

Dr. W. M. Myers, General Chairman for the afternoon session, introduced the "Cooperative Panel" by stating that, "with careful, long-continued therapy (research), the patient (the wheat plant) can be maintained in fairly good health for a long time". There is hope for security in the fight against rust, but no room for complacency. There are many thousands of lines of wheat to test. The possible range of environmental conditions, and the range of variability of the pathogen, are almost unlimited. Even with maximum support, no one station could possibly study all the interactions between host, parasite, and environment. Cooperation between stations is essential. Cooperation multiplies the number of hands at work; it gives each investigator the benefit of the others' work, allows the study of behavior under a very wide range of environments, and makes it possible to get a large sample of conditions in a short time. Cooperation among Canada, the United States, and Mexico is well established.

Other countries must be brought into the cooperative program. The program is now being extended to Australia, Kenya, South Africa, and Spain, as well as to South America, on an informal basis.

Dr. B. B. Bayles was Moderator for the "Cooperative Panel".

Winter wheats being increased:

L. P. Reitz: New varieties of hard red winter wheat recently released include Quanah, Ponca and Sioux. Quanah is grown in Texas. It is resistant to leaf rust and some races of stem rust. Ponca is intended for the Oklahoma and Kansas areas. It is resistant to leaf rust and hessian fly. Sioux is adapted to the Nebraska region. It is resistant to bunt.

I. M. Atkins: Two strains with leaf rust resistance in the mature plant stage are being increased in Texas. Two other lines, being increased for south Texas, are resistant to 15B, and may affect the build-up of 15B in Texas.

A. M. Schlehuber: Comanche x Blackhull-Hard Federation C.I. 12517 is being increased in Oklahoma. It has high resistance to leaf rust. The variety is supposed to be red chaffed, but it was found to be segregating for white chaff color. The segregation may be due to out-crossing, but some cytological abnormalities may be associated with it. Three thousand bushels of the increase had to be disposed of as commercial wheat to the elevators.

C. O. Johnston: Ponca was recently released in Kansas. It has the highest field resistance to leaf rust of any variety tested. It was resistant to stem rust race 11 in two preliminary tests.

Durum wheats being increased:

R. M. Heermann: Ld. 356 is being increased at Brawley. It is a stop-gap variety. It has no resistance to 15B, although it has some tolerance to it. It has better test weight than Nugget or Stewart.

Hard red spring wheats being increased:

J. W. Gibler: 70% of the wheat acreage in Mexico is in Kentana, which is resistant to 15B but susceptible to race 49. We are now increasing Egypt-Timstein-Mayo. Yaqui-Kentana stood up well in South America, and is equal in quality to Yaqui. It is being increased. Kenya x Mentana^2 x Supremo, which is resistant to 15B and to 49, is also being increased. Menkemen, a sister selection of Lerma, is a soft white wheat with resistance to 15B. It is being increased for release in Colombia.

A. B. Masson: C. T. 186 is being increased on 150 acres in California. We hope to get it back in time for spring sowing. It is a selection from C. T. 181. 50% of the lines in C.T. 181 were resistant to 15B. The resistant lines were bulked to make C. T. 186. It has McMurachy resistance to rust. We hope that its milling and baking quality will be as good as its agronomic characters.

P. J. Olson: Why is hard red winter wheat not grown in souther Minnesota?

E. R. Ausemus: Scab is an important factor in wheat production in southern Minnesota. Also, wheat there has to compete with the soybean crop. The hard red spring wheats that are being increased by Minnesota, North Dakota and South Dakota, are only stop-gap varieties.

Increase in California is expensive; it costs 12 cents a pound, plus freight, to produce wheat there. Timing is also very difficult, although we have had good success. We sent out eight pounds of seed one fall, and got back 43 bushels. At present we are increasing two Frontana-Thatcher crosses on three acres each, Timstein-Henry on 1 acre, Rushmore^2-Surpresa (1 bushel), Ld.356 on three acres, and C.T. 186 on 5 acres, to be divided among the three states. One pound, half pound, and smaller lots are being increased of four of Dr. Waldron's wheats, 32 wheats with seedling resistance to 15B and other races, and a number of plant selections. The sawfly-resistant lines which are being increased, 1750 x Rescue, 1754 x Rescue, and Rescue x Thatcher, have better quality than Rescue.

Possibly there should be a government station in California where winter increases could be done under careful supervision and control. There has been dissatisfaction with the present system, where the increase is done by farmers. We want to be able to increase many small lots, and we want to get the seed back about two weeks earlier than we do now. This is particularly important.

W. M. Myers: Dr. Ausemus is right in saying the increase program is expensive. The Minnesota station has about $30,000 worth of increase in California this winter. Some of this material may be of no use, some may turn out to be very valuable.

H. A. Rodenhiser: Care must be taken to see that only material that has a chance of turning out well is sent to California for increase, because costs are high at the Brawley Station. A station may be set up under federal control in the Salt River Valley in Arizona. It might help solve the increase problem.

I. M. Atkins: When the irrigation dam is finished in the lower Rio Grande Valley of Texas, it may be possible to make increases there and ripen the crop two to three weeks earlier than in California.

Sources of germ plasm and cooperative testing:

B. B. Bayles: Mark Carleton started collecting wheats from all over the world. There are now about 13,000 to 14,000 wheats in that U.S.D.A. collection. We try to make this source of germ plasm available, and we try to evaluate it. Until a few years ago we did not have the help or facilities to do this systematically. Some of the material has gone through the disease garden in St. Paul. The bulk of it has been screened in Mexico by Dr. Borlaug. Since 1948, many potential rust resistant parents have been selected on the basis of Borlaug's screening test. As new introductions (several hundred, up to a thousand each year) come in, they are grown at the quarantine station at Sacaton, Arizona, where humidity is so low that there is practically no disease build-up. The seed is harvested in May, and sent to Dr. Borlaug for inclusion in his summer nursery in Mexico. We also send to Mexico each year from 1,000 to 3,000 lines of breeding material, and 400 to 500 lines of winter wheat, for inclusion in the 15B test. Anywhere from 2,000 to 8,000 lines, sent down by the U. S. Department of Agriculture, have been tested by the Rockefeller Foundation in Mexico each year.

In 1949 a small nursery of rust resistant wheats from the world collection was sent to several locations in the United States and in Mexico. The program was expanded to include South America in 1950. In 1952 about 450 wheats which showed promise in early tests, were tested in Canada, the United States, Mexico, South America, Australia, Kenya, South Africa, Spain and India. About 1,000 wheats, including the 450 from the world collection, and a large number of breeding lines, were grown in Mexico and 5 South American countries in 1952.

Processed reports giving the data on reaction to rust of the wheats from the U. S. D. A. World Collection when grown in Mexico and in the other cooperative tests in other countries are available at Beltsville.

We are now at a point where some reorganization is required, so that interested plant breeders will participate more actively. We want to put into a uniform international nursery only those materials which have shown up well in local tests, and we want to make the tests of mutual benefit, rather than have most of the material coming from North America. The nursery contains 500 to 600 lines, of which 100 to 200 might be from the world collection, and the rest advanced breeding material.

N. E. Borlaug: We have gained a great deal by taking part in this program. In two years, we have learned how our varieties react under a range of conditions that might not have occurred in Mexico in 10 or 15 years, if at all. We should include the same outstanding parental varieties from year to year but replace the breeding materials submitted by various stations as their programs warrant such changes. Some lines tested in the past have been quite mixed; perhaps more attention should be paid to purity and uniformity of lines in the test.

J. G. Dickson: The uniform nursery should include a permanent set of varieties, representing selected genes, to accumulate information and trace trends in various parts of the world. The rest of the nursery could be a flexible group of lines in the final stages of evaluation.

R. F.Peterson: Wheat varieties should be classified into groups according to genes for rust reaction, and at least one representative of each gene group should be included in the permanent list for the international nursery. Varieties intended for use as parents at the Cereal Breeding Laboratory at Winnipeg are crossed with susceptible and resistant varieties to determine if they carry new genes for resistance.

H. A. Rodenhiser: The parentage of the different Kenya wheats is not generally known. I would like to get the information available at the Winnipeg laboratory.

T. Johnson: I went through the Kenya annual reports. Some of the lines go back to the early work before the first world war. Evans did the work in Kenya at the time of the first world war. It was taken over by Dr. Dowson, later by Dr. Burton, then by Lathbury. Dr. Thorpe tried to clear up some of the confusion in the Kenya reports, but was unable to trace the lines back to the original parents. Some can be traced back a good distance with study.

B. B. Bayles: There is some indication that the material used in early work in Kenya came from Egypt.

E. R. Ausemus, B. B. Bayles, J. G. Dickson: A start should be made on learning the actual genic make-up of the available materials. A committee should be formed to do this work. Dr.Bayles has a list of about 100 wheat varieties from the world collection, representing a large number of potentially valuable genes. This group of varieties might be sent to various laboratories making rust studies to test against the particular races that are important in their area, under their own greenhouse conditions. In a few seasons, there would be a tremendous amount of information on these potential parental types.

N. E. Borlaug: We have pure rust races to work with, but not necessarily pure varieties of wheat. A first step in such a program would be to make sure that the seed was pure, and to have it all come from the same source. All the data obtained should then be correlated at one place. Drs. Bayles, Rodenhiser and Lowther, in the U. S. Department of Agriculture, might be the best group to handle this program.

W. C. Broadfoot: We are interested in sawfly resistant wheat. Would it be possible to check the world collection for solid stemmed durums and spring wheats?

B. B. Bayles: New introductions all go to the sawfly area for test after being grown in the quarantine nursery at Sacaton.

R. M. Heermann: 6,500 spring wheats, 3,400 winter wheats, and 900 durums have been grown in the sawfly area. Many have been examined for solid stems. Of 400 durum wheats examined at Fargo, 20% had solid stems. Out of 300 lines examined in detail at Minot, one variety of common wheat with a hollow stem had sawfly resistance.

Question: Should the 100 varieties mentioned be tested to individual races of both leaf and stem rust?

B. B. Bayles: There would have to be separate sets of varieties for testing against stem rust and leaf rust races. Individual investigators should test with the races they feel are important in their areas.

E. C. Stakman: That would be a cumbersome, hit-and-miss procedure. Anyone making tests should have an adequate sample of any rust he is using, rather than just the rust from his own area. No one can say what an adequate sample really is, but it should contain a range of biotypes of the particular race.

N. E. Borlaug: If you use composites, you may be introducing races or biotypes into areas where they did not occur before.

W. M. Myers: There are two problems involved. One is the practical one of finding wheats that will be resistant over a wide area, and involves the use of composite samples of rust. The other problem is to determine the genic composition of varieties, to break down the wheat species into a series of genetic factors controlling resistance to specific forms of rust. To do this, people at each station would have to work with collections of each race from their own area.

E. C. Stakman: To locate genes for resistance, you must inoculate with individual biotypes of rust.

E. R. Ausemus: Would it be possible to standardize the terms and symbols in taking notes in such a way that the data from all stations would be uniform and could be transferred to punch cards for correlation?

W. E. Sackston: Dr. Goulden helped work out a standard form for the world catalogue of genetic stocks of wheat for the F. A. O. The data is intended to be recorded on punch cards. It appears to be a workable system.

J. B. Harrington: We might need more details than are on the F.A.O. punch cards.

E. C. Stakman: Any system would be imperfect. The really important thing is to standardize and record the prevalence of rust, the infection type, and the variability of infection types. Types should be definite, readings should not be merely "susceptible" or "resistant".

J. G. Dickson: A committee should be appointed to study standardization in taking rust notes, and to develop a possible punch card system.

Tuesday evening, January 6.

Dr. Ruby Larson was Chairman of the "Special section on genetics, aneuploids, and species building".

SPECIES BUILDING IN WHEAT AND WHEAT RELATIVES FOR RUST RESISTANCE

R. C. McGinnis

In the summer of 1951, a species building program was started at Winnipeg, with the aim of transfering rust-resistant genes from related species and genera to common wheat varieties. Since new races of rust are continually appearing, it was felt that all possible sources of resistance must be exploited in order to combat the ever-present rust threat.

Briefly, the project undertaken consists of testing for reaction to races of stem and leaf rust, the available wild wheat relatives (species of *Aegilops*, *Agropyron* and *Haynaldia*), building new species (amphiploids) from crosses between the resistant species and tetraploid wheats, and finally transfering the resistant genes from the amphiploids to common wheat varieties through a backcross program.

To date, 18 *Aegilops* species, 4 *Agropyron* and one *Haynaldia* have been tested to race 15B, as well as to other common races of stem and leaf rust. The few showing resistance have been crossed with tetraploid wheats with some fertility usually resulting. Only a small number of F_1 intergeneric hybrids have been treated with colchicine to induce chromosome doubling but no success can be reported as yet.

Fifty-nine amphiploids developed elsewhere were made available for testing to stem and leaf rust. The majority had a susceptible reaction to race 15B and were unsuitable for breeding material. However, some of those having *Ae. ovata*, *Ae. caudata*, *Ae. speltoides* and *A. obtusiusculum* as one constituent species gave good resistance to all races of stem rust rested and also had excellent leaf rust resistance in most cases. These amphiploids are being crossed with Redman wheat in an attempt to transfer their resistant genes to this variety.

A program to obtain the 15B resistance of Khapli is under way. Khapli has been used in crosses with Redman and H-44 and a small F_3 population has been obtained. Backcrosses to the common wheat parents were made in the F_2. Unfortunately, insufficient material was available for testing to 15B in the early generations, but limited tests just completed on the F_3 and selfed backcrosses showed a complete loss of the Khapli resistance.

REPORT OF WORK WITH ANEUPLOIDS, CHROMOSOME SUBSTITUTIONS AND SPECIES BUILDING AT THE UNIVERSITY OF ALBERTA.

John Unrau

Aside from special soft and winter wheat breeding projects, work at the University of Alberta is largely centered around developments of aneuploids, substitution lines, amphiploids and crosses with genera and species having high resistance to rust. With the establishment of a special Dominion Rust research grant at this University the latter two phases of our work will be greatly intensified.

I. <u>Work with Aneuploids and Substitution Lines</u>

A. Development of monosomic lines of Lemhi and Thatcher and of reciprocal chromosome substitution lines of these varieties.

Most of the work is now finished in the development of monosomic lines of these two varieties. There are however, still a number of chromosome lines in which additional backcrosses have to be made before this phase of the work is completed.

So far as the reciprocal substitutions are concerned, this phase of the work necessarily is behind and it will be some time before these lines are established.

B. Leaf rust reaction of Chinese spring lines with different substituted Thatcher chromosomes.

While Chinese Spring and the remaining 18 lines were resistant, substitution line X was highly susceptible. The writer does not know of a study of inheritance of rust reaction involving these two varieties, but in the cross Chinese Spring x Federation 41, one pair of factors was found to be involved. Presumably, then, chromosome X of Chinese Spring is responsible for the leaf rust resistance in that variety.

It is impossible to say from these data alone that chromosome X of Thatcher is mainly responsible for susceptibility in Thatcher, but very likely that is the case.

II. <u>Transfer of Rust Resistance from Wheat x Grass Amphiploids using Whole Chromosome Substitutions</u>

A. Rust reaction of amphiploids and grasses were tested in 1952.

Since the information on amphiploids and grasses is largely lacking or at least incomplete, it was necessary to test these before any additional crossing work could be undertaken. Moreover, since most of the grasses that will be considered are

cross-pollinated there is danger that results that have been obtained may be applicable only to the particular seed lot used.

Seedings were made from material vernalized for approximately 40 days and also from unvernalized seed. Most of the vernalized material failed to emerge although utmost care was used in planting.

A fairly high proportion of the material obtained failed to germinate, so that our information is complete only on some of the types obtained.

Below is tabulated the information obtained on a number of amphiploids and grasses.

Amphiploid or Grass	Stem Rust	Leaf Rust	Growth Habit	Chrom. No. (2n)
T. timopheevi x Ae. uniaristata	R	R	S	
T. timopheevi x Ae. umbellulata	R	R	S	42 pairing not too good
T. timopheevi x Ae. speltoides	R	R	S	
" " x Ae. caudata	R	R	S	42 good pairing
" " x Ae. squarrosa	S	S	S	
" " x Ae. bicornis	S	R	S	42 good pairing
T. dicoccoides x Ae. umbellalata	R	R	W	
" " x Ae. speltoides	R	R	W	
" " x Ae. caudata	S	S	W	
" " x Ae. sharonensis	R	S	W	
T. aegilopoides x Ae. speltoides	S	S	W	
T. turgidum x Ae. speltoides	R	R	S	
T. dicoccoides x Ae. uniarestata	S	R	W	
T. " x Ae. squarrosa	R	S	W	
" " x H. villosa	R	R	W	
T. timopheevi x T. monococcum	R	R	S	
T. aegilopoides x Ae. umbellulata	S	R	S	
T. monococcum x Ae. uniarestata	MS	MS	SW	28 pairing good
Agropyron caespitosum	R	R	W	70
" orientale	?	?	S	28
A. elongatum	R	R	S	14
" kirkii	R	R	S	42
" elongatum	R	R	S	70
Aegilops biuncialis	R	R	S	28
" ovata	S	R	S	28
" cylindrica	R	S	S	28
" caudata	R	R	S	14
" bicornis	R	S	S	14
" speltoides	R	R	S	14
" squarrosa	R	S	S	14
" longissima	R	R	S	14

Amphiploid or Grass	Stem Rust	Leaf Rust	Growth Habit	Chrom. No. (2n)
Ae. sharonensis	R	S	SW	14
" comosa	R	R	W	14
" triaristata	R	R	S	42
" varialis	R	R	S	
" columnaria	R	R	S	28
" triuncialis	R	R	S	28
" ventricosa	R	R	S	28
" crassa	VS	VS	S	28
" crassa	VS	VS	S	42
" umbellulata	R	R	S	14

While no general conclusions are warranted from these results of the amphiploids and of the aegilops species themselves, a few interesting results might be pointed out.

Firstly, the reaction of the amphiploids is not always what might be expected from the reaction of the constituent species. Thus, T. timopheevi and aegilops squarrosa were both resistant to the stem rust races present in the nursery, yet the amphiploid was highly susceptible. A similar situation exists in the case of Ae. bicornis. Obviously there must be factors for resistance in both species, but these factors are inhibited from being expressed when the species are combined.

A similar, though perhaps simpler situation is found in the amphiploid involving T. dicoccoides and Ae. caudata. Here the caudata resistance was not expressed when combined with T. dicoccoides presumably because a factor or factors in T. dicoccoides interacted and inhibited expression of the Ae. caudata resistance. This same situation appears to exist in the case of T. aegilopoides x Ae. speltoides. Apparently factors in the A genom are inhibiting the action of resistance genes present in the caudata genom.

In making substitutions into wheat from such amphiploids it is, therefore, necessary to determine:

(1) The chromosome or chromosomes inhibit the expression of resistance present in the grass from which it is to be transferred.

(2) The chromosome that carries the resistance in the grass species present in the amphiploid.

Assuming that there will be the two types of amphiploids, i.e. those where the resistance present in the constituent species is expresses and those in which it is not expressed, we will proceed in the following manner:

1. Crosses will be made to Lemhi monosomics or preferrably even nullisomics. There will be twenty-one different F_1 populations, each deficient for a different Lemhi chromosome. All chromosomes of the grass species that is a constituent of the amphiploid will be present in single does. In the case of one or more of these F_1

lines the chromosome that in Lemhi actively enhances susceptibility will be absent, add the resistance factor from the grass should have an opportunity to express itself even though this may not be in the form of complete resistance.

2. Identification and substitution of chromosome from the grass species carrying resistance with the chromosome known to be responsible for susceptibility. This presumably could be accomplished in two ways.

(a) Backcrossing the F_1 to critical nullisomic and saving only the resistant F_1's for further backcrossing.

(b) Crossing F_1 to critical nullisomic and establishing all the different grass chromosomes addition lines. Each line would have the same 20 wheat chromosomes but a different grass chromosome. If there are seven possible, one line should be resistant. This would, of course, also be the substitution line which is to be developed.

III. <u>Work Underway and to be Undertaken this Summer</u>

A. Chinese Spring x <u>Haynaldia</u> <u>villosa</u> addition lines. This material was obtained last spring from Dr. Beal Hyde. Unfortunately, it came too late to be included in the rust nursery in 1952.

I have been informed that the <u>Haynaldia</u> <u>villosa</u> used in developing this material was later found to lack resistance. If that is the case this material would be worthless for any substitution work. We are intending to test it in the rust nursery in 1953, and if any of the chromosomes carries resistance there is some chance that it can be identified.

B. Crosses between all Lemhi monosomics and the amphiploid of <u>T. timopheevi</u> x <u>Ae</u>. <u>caudata</u> were made last year. The F_1's will be grown in the nursery this year, and an attempt will be made to determine if possible the chromosome or chromosomes responsible for susceptibility in Lemhi.

It is not certain how the F_1 will behave. If the resistance of the amphiploid acts in a dominant manner, there is little likelihood that any differentiation between different chromosomes will be possible, if on the other hand it acts as a recessive we may be able to learn something.

C. Crosses to be attempted this summer. - Crosses involving each of <u>T.</u> <u>monococcum</u>, <u>T.</u> <u>dicoccum</u> and <u>T.</u> <u>vulgare</u> with each of: <u>Agropyron</u> <u>cristatum</u>(2n=14), <u>Agropyron</u> <u>elongatum</u> (2n=14), <u>Elymus</u> <u>junceus</u> (2n=14), <u>Elymus</u> <u>Caput-medusae</u> (2n=14) and resistant <u>Haynaldia</u> <u>villosa</u> will be attempted this coming summer.

I In a program of whole chromosomes substitution the identification of chromosomes carrying resistance and the actual substitution of chromosomes is greatly simplified if diploids only are used.

We will attempt crosses with <u>Elymus</u> because resistance likely is different from any hitherto used, and derivatives from this source may be valuable.

STUDIES ON THE GENETICS OF RUST REACTION IN WHEAT, SUMMARY OF RESEARCH UNDER R & M PROJECT #2213-2

C. R. Burnham, assited by R. L. Livers, L. Inman, J. Longwell, J. Miller, E. Clark, and E. Turcotte, cooperating with E. R. Ausemus

The genetic analysis of rust resistance in the varieties and selections which were being used in the breeding work has been the subject of several thesis problems at Minnesota.

Recently a program was started to use the monosomics to determine the chromosome or chromosomes carrying these factors. To place the studies on a firm basis, crosses between normal Chinese and the resistant varieties have been made also and analysed in F_2 and F_3. In several cases, F_2 segregations which fitted a 3:1 ratio reasonably well proved to be due to the interactions of several genetic factors when analysed in F_3.

The results and the work in progress on these and the monosomic crosses will be summarized here.

Frontana is resistant to many races of stem and leaf rust. When crossed with Chinese and tested against race 56 of stem rust, resistance was found to be dominant and due to two duplicate factors. From F_3 lines segregating 3:1, it is planned to establish the two stocks carrying only one of these factors. These will then be available for use as testers for further studies of the genetics of rust reaction.

Tests in F_2 with the monosomics (some also tested in F_3) indicate that one of these factors for resistance to race 56 is in chromosome 6. The other factor has not been located, only monosomics 14 and 15 remaining to be tested. Chromosome 6 of Frontana does not carry a factor for resistance to race 36.

It is planned to use the above material for leaf rust tests also.

Other varieties and selections being studied by the same methods are:

1. II-44-22, a selection from Mida x Kenya 117A, for resistance to 15B and other races of stem rust. F_2's are ready for testing with most of the monosomics.
2. II-39-2 a selection from Premier x (Bobin^2-Gaza) for its resistance to leaf rust, this selection being the one in which Martinez _et al_. found at least 5 separate but closely linked genetic factors, each segregating 3:1 and responsible for the reaction to a single race. F_1's with the monosomics are to be tested, then F_2's will be produced.
3. Lee for its stem and leaf rust resistance. This is being studied by A. G. Plessers as a thesis problem. In tests against race 56, he has found a ratio approximating 9 resistant to 7 susceptible in F_2, but deviating in the direction which indicates linkage of

the two factors. Monosomic tests indicate chromosome 10 is the one carrying the factors for resistance to race 56, and also to several other races. His tests for leaf rust reaction are in progress.

4. A tabulation of the data from some earlier tests made by Ausemus on F_3 lines from several monosomics x Newthatch and tested against race 17 suggested that monosomic 19 was involved. F_2 populations are now available for testing. (This would agree with Sears' results by a different method).

5. Other characters are being studied also in the hope of finding markers; the hairy node of Mida, a virescent plant was found in one F_2 population, and red coleoptile color is present in several of the crosses. Some of the difficulties encountered which have hindered progress:
(1) The cytological identification of monosomics in F_1 has been deficient in some crosses, because of a high frequency of univalents in F_1. Cytological study of a few plants from each F_2 of the crosses has given better results.
(2) The amount of seed obtained from monosomic plants is variable. In too many cases, F_1 plants have been determined to be monosomic; but the seed yield was either zero or so low that they were of no use. We are gradually going over to the procedure of testing a sample of F_2 plants from F_1's which have yielded an adequate number of seeds; the original Chinese parent having been determined to be monosomic.
(3) What appear to be natural crosses have been found in the Chinese variety grown in the field. It may be higher in the monosomics.

As a contribution to the general work, we have prepared a summary of the ratios expected in F_2 and in F_3 from segregations of one factor and the various 2-factor interactions; in normal crosses and in crosses with the monosomics. Copies are available for distribution.

DETERMINATION OF THE NUMBER OF DIFFERENT GENE LOCI INVOLVED IN STEM RUST RESISTANCE OF THE BREAD WHEATS

L. H. Shebeski

The work to be reported is part of the research program on stem rust of wheat which is being conducted at the University of Saskatchewan under a grant from the Canada Department of Agriculture.

In order to determine the number of gene loci involved in stem rust resistance in the bread wheats it will be necessary to make diallel crosses between a large number of the bread wheats which have been reported to have some resistance to stem rust.

The first thirty-six crosses for this study, with a minimum of 30 seeds and an average of 45 seeds being obtained per cross were completed last summer. The parent varieties were K117A, Gabo, Lee, Red Egyptian, Timstein, Egypt NA95, Thatcher and Marquis. In consultation with Dr. E. R. Ausemus, the choice of the first group of parental varieties

was made on the basis of their potential usefulness in rust breeding programs. Four of the varieties, K117A, K58, Red Egyptian, and Egypt NA95 are at least partly resistant to race 15B. By including the rust-susceptible variety Marquis it will be possible to determine the manner of inheritance of the rust resistance carried by each variety while by intercrossing the resistant varieties the allelism of the genes involved can be established.

Twenty F_1 plants of each cross were grown in our greenhouses this past fall and were harvested shortly before Christmas. For the crosses in which the minimum of 1500 seeds was not obtained, additional F_1 plants are being grown.

Four of the thirty-six crosses produced only dwarf plants. These dwarfs sent up a number of narrow and stiff leaves from the crown. There has been no sign of culms being produced up to the present, the plants maintaining heights of from four to six inches.

The crosses were:

Timstein x Marquis
Timstein x Red Egyptian
Gabo x Marquis
Gabo x Red Egyptian

In addition the cross Gabo x NA95 gave a segregation of 12 dwarf: 8 normal.

It is hypothesized that Gabo and Timstein carry a factor or factors which in combination with a factor or factors in Red Egyptian, Marquis and NA95, produces dwarfs. This hypothesis is being tested.

A minimum of 1500 F_2 plants will be grown for each cross next summer under an artificial epidemic of race 56 in an irrigation nursery. A few F_1 plants will be included so as to determine whether resistance is dominant or recessive in each cross.

Genetic ratios will be determined on the basis of segregation in F_2. If the pattern of segregation is not consistent from cross to cross involving some of the parents, ratios for such crosses will be checked in F_3.

For a number of the crosses, seedling reaction to 15B will be checked in F_3 in the greenhouse during the winter of 1953-54.

THE TRANSFER OF RUST RESISTANCE TO HIGH QUALITY BREAD WHEATS FROM OTHER VARIETIES AND SPECIES, AND THE EFFECT OF GENES FOR RUST RESISTANCE ON QUALITY

D. R. Knott

The work to be reported is part of the research on rust resistance which is being carried on at the University of Saskatchewan under a grant from the Dominion Department of Agriculture.

A. The Inheritance of Resistance to Stem Rust Race 15B.

Sixteen lines of wheat, very resistant to 15B in both the seedling and mature plant stage, and resistant to Race 56 in the mature plant stage, were obtained from the Dominion Laboratory of Plant Pathology at Winnipeg. Two of the lines were extremely late and segregated for many agronomic characters. In these lines, selected single plants were harvested from among those that were early enough to develop seed. Fourteen of the lines appeared uniform and were crossed to Marquis. In addition, two of the lines which were derived from Frontana-Thatcher crosses were backcrossed to Thatcher.

The F_1 plants of the crosses are in the greenhouse now and a few seedlings of each cross will be tested with Race 15B to see if resistance is dominant or recessive. The F_2's will be grown in the field next summer and subjected to an artificial epidemic of Race 56. The F_3 lines will be grown in the greenhouse and tested for seedling resistance to Race 15B.

B. Transfer of Stem Rust Resistance to the Bread Wheats from Other Species.

An attempt is being made to transfer rust resistance to bread wheats from three wheat species, Triticum persicum variety Black Persian, Triticum durum variety Golden Ball, and Triticum hermonis.

Previous attempts to transfer rust resistance from Black Persian to bread wheats have been unsuscessful. Reciprocal crosses were made between Black Persian and Marquis and Black Persian and Chinese. Some of the F_1's are being grown in California and more will be grown in the greenhouse for backcrossing to Marquis and Chinese.

Golden Ball was crossed with Marquis and Red Bobs and the F_1's will be grown in the greenhouse this spring.

Triticum hermonis had been expected to be stem rust resistant. However, in the field last summer it proved to be moderately susceptible to the stem rust races used in the artificial epidemic although resistant to a natural leaf rust epidemic. Marquis and Red Bobs were crossed with T. hermonis and the F_1's will be grown in the greenhouse this spring.

C. The Effect on Bread Wheat Quality of Three Genes for Rust Resistance from Agropyron elongatum.

Shebeski and Wu (1952) have shown that a wheat-Agropyron derivative developed by Shebeski and called Perennial Wheat, has three dominant genes for rust resistance. Several tests have indicated that Perennial Wheat has resistance to Race 15B. In recent cytological examinations, Perennial Wheat was found to have stabilized with a 2n chromosome number of 56. However, hybrids with wheat are fully fertile.

A backcrossing program has been started to transfer the rust resistance of Perennial Wheat to five rust susceptible wheat varieties chosen

to represent various quality levels. Marquis has been selected as a high quality bread wheat, Garnet and Red Bobs as low quality bread wheats, Lemhi as a soft white wheat and S 615 as a poor quality solid-stemmed wheat. By the end of the winter the first backcross to all five varieties will have been completed. Because the Perennial Wheat resistance is dominant the backcrossing will proceed rapidly.

The intention is to carry on the backcrossing for a number of generations and then compare the quality of the reconstituted lines with the quality of the corresponding recurrent parent. Since selection will be for three genes, three blocks of chromatin from Perennial Wheat will be transferred to each of the five varieties. The size of the blocks will decrease as the number of backcrosses increases. When completed, the tests should show whether the five varieties can be reconstituted without change in quality, and, if so, how many generations it will take. Similarly, if the three blocks of chromatin have an effect on quality, it will be possible to study their effects in five different genic environments.

LOCATION IN SPECIFIC CHROMOSOMES OF GENES RESPONSIBLE FOR RUST RESISTANCE

B. C. Jenkins

A few of the genes responsible for rust resistance have been located by various workers to date. The following table, which is undoubtedly incomplete, shows some of the known gene loci and their location.

Variety	Number of non allelic loci involved	Location as to chromosome
Red Egyptian	2	VI and XX
Hope	2	VIII (incomplete)
Timstein	2	X and X
Thatcher	3	XIX (incomplete)
McMurachy	1	XX

Note: It is believed that the McMurachy gene and one of the Red Egyptian genes are alleles.

The method by which we propose to locate the chromosomes carrying genes for a given source of rust resistance follows. The resistant variety is crossed with each of the 21 aneuploids of Chinese Spring. Since only a limited number of these lines can be maintained in the nullisomic condition, cytological examination is necessary to ensure that the resistant variety is crossed with monosomes. For an objective, it is suggested that a minimum of 15 seeds are required as a total from at least two plants for each of the 21 variety-monosomics and reciprocal disomic crosses. The F_2 consisting of from 1500 to 2000 plants for each chromosome line is grown as plant progeny rows under rust epidemic. The location of the critical chromosome or chromosomes is based on disturbed ratios. The inclusion of normal disomic populations is considered to be an insurance measure and may provide valuable information. It is believed that there is no need

for cytological examination in the F_1, however, some means of controlling pollination in this generation should be taken.

It has been possible to set up three complete series. These involve Gabo, a variety from Australia; Egypt NA95, an Egyptian variety; and P.W. (Chinese $Spring_2$ x Agropyron elongatum), a wheat-like segregate with three dominant genes for resistance reported by Shebeski and Wu-Sci. Agr. 32:26-35, 1952. Portions of the F_1 from all the crosses (a total of 69) are being increased in the greenhouse. Owing to considerable sterility in the Egypt NA95 crosses and because of possible chromosome irregularities in the P.W. crosses, we may have to delay their F_2 analysis. However, we do expect to make a complete F_2 analysis of the Gabo series in the summer of 1953.

RUST RESEARCH AT DAVIS, CALIFORNIA

C. A. Suneson

The rust work at California is unique in many respects: (1) there is year-around persistance of red spores, and no known observation of rust on barberry; (2) previous to the release and widespread use of resistant varieties (1922-41) stem rust was observed in every year, produced significant damage about every fourth year, and had driven wheat from certain "hazard" areas; (3) wheat comprises less than 9% of our crop acreage, and is variously further dispersed by mountains and deserts; (4) our success in breeding (1940-52) was based on a degree of resistance (derived from Hope) generally considered "inadequate" since it involved a mixture of lines having 0, 1, 2 or even 3 type pustules under epidemic conditions; (5) we have not been contaminated by 15B from Western Mexico; (6) only races 11, 17, and 56 have been observed (1940-52) in the state; (7) it is "believed" that one or more variant biotypes, with greater virulence on some derivatives from Hope, have recently developed.

Our present breeding programs seek to: (1) hold previous breeding gains, and (2) add greater genetic protection. In this, backcrossing is our breeding method, and gene differentiation by naturally occurring biotypes and races our tool. Race identification and differentiation are only of academic interest here.

Mr. Nyquist has undertaken a comprehensive cytogenetic analysis of the leaf and stem rust resistance recovered from Timopheevi in the derivative, Wis. 245 C.I. 12633. This promises to be the greatest single fundamental contribution from the California group on rust. We place a high value on this resistance despite its failure to protect from certain cultures.

Dr. Schaller and I are utilizing in our breeding programs; (1) diverse resistance derived from Hope; (2) diverse resistance from Kenya (F.P.I., 117526, Eureka, and Gabo); (3) C.I. 12633; and (4) Agropyron derivatives. These programs are sufficiently advanced and the genes so different that we believe that we will be able to "stay ahead" in providing continued effective control of stem rust in California.

WHEAT GENETIC AND CYTOGENETIC RESEARCH AT KANSAS STATE COLLEGE

J. W. Schmidt and E. G. Heyne, Department of Agronomy, Elizabeth McCracken, C. O. Johnston, and W. C. Haskett, Department of Botany and Plant Pathology. Investigations cooperatively with the Division of Cereal Crops and Diseases B.P.I.S.A.E., U.S.D.A.

Inheritance Studies of Leaf Rust Reactions

Studies are underway involving diallelic crosses of the eight leaf rust differentials. According to results obtained with leaf rust physiologic races 9, 15, and 58, Democrat and Mediterranean have the same factor or factors for resistance to race 9 and the same factor or factors for susceptibility to races 15 and 58. In Malakof - Democrat crosses, two factors governed the recessive resistance of Democrat to race 9, and one dominant factor the Malakof resistance to races 15 and 58.

The leaf rust differentials are also being crossed to Pawnee winter wheat in order to study the genetics of the leaf rust reactions of the differential varieties against a common parent, and then being backcrossed to Pawnee to obtain the differential reactions in an otherwise common genetic background. The Chinese monosomics of Dr. Sears' will be included in crosses with the differentials this winter.

Results of testing crosses of Timstein x Pawnee and Timstein x RedChief suggest that Timstein has one major recessive factor and one or more modifying factor governing seedling and adult plant resistance to leaf rust races 5, 9, 15, 44 and 126. In addition, Pawnee has one major factor for seedling resistance to race 9 that is non-allelic to and partially epistatic to Timstein's factor but linked with it.

Inheritance Studies of Stem Rust Reaction

Stem rust reaction inheritance studies are now underway as part of the _Triticum_ x _Agropyron_ hybridization project. One Agrotricum parent used, Chinese[2] x _Agropyron_ _elongatum_ obtained from Dr. L. H. J. Shebeski, has 3 dominant factors for stem rust resistance according to Dr. Shebeski and Wu. Crosses of this Agrotricum with Pawnee appear to substantiate the 3-factor hypothesis, although the populations studied have never been of ample size.

Aneuploid Research

The Chinese monosomic stocks obtained from Dr. Sears are being backcrossed to Pawnee winter wheat in order to obtain winter habit monosomic stocks for field work and greenhouse research with the winter wheats.

Cytologic Problems

Since some of the South American wheats are being used as sources of resistance to leaf rust in the wheat breeding program, reports of their meiotic instability have caused some concern. The variety Sinvalocho and its hybrids with Pawnee are being studied to determine the source and mode of inheritance of the instability.

Meiotic indices are being obtained on the advanced line-bred Agrotricum strains for parental evaluation on purposes in the breeding program. Also some study will be made of chromosome numbers and pairing behavior in certain of these strains.

STUDIES OF GENES IN WHEAT AND RELATED SPECIES
E. R. Sears

A project has been under way for several years for determining which chromosomes carry the major genes for stem-rust resistance in the varieties Timstein, Red Egyptian, Hope, and Thatcher. This work is being done in collaboration with Drs. Rodenhiser and Lowther. Genes for resistance have been located as follows: Timstein--two genes on chromosome X, apparently responsible for all of the variety's resistance; Red Egyptian--a gene on chromosome XX and one (possibly two) on chromosome VI, each more or less effective against nearly all races, and interacting with each other to give increased resistance to certain races; Hope-- a gene on chromosome VIII responsible for resistance to half the races tested (17, 19, 38), with another gene not yet located presumably providing resistance to the other races (11, 36, 56); Thatcher--a gene on chromosome XIX giving resistance to about half the races (17, 19, 59), and a gene not yet located providing resistance to the others (11, 36, 38, 56). Only XIV has not been tested.

A second project is to combine resistance genes from different varieties and note the interactions involved. Chromosome X from Timstein is being combined with VIII from Hope, XIX from Thatcher, and VI and XX from Red Egyptian. Each of these five chromosomes is also to be checked in dosages of three and four.

A third project is to transfer leaf-rust resistance from Aegilops umbellulata to common wheat. Ae. umbellulata has a high type of resistance, effective against all eight races tested, but inability of its chromosomes to pair with those of wheat makes transfer of the resistance impossible by ordinary plant breeding methods. Consequently a new method has been devised. In applying this method the first step was to add the chromosome carrying resistance to the full complement of wheat chromosomes. Resistance of the resulting alien-addition race was excellent, but vigor and fertility poor. By means of x-rays an attempt is being made to substitute for a piece of wheat chromosome an Aegilops segment containing the gene or genes for resistance but not the deleterious genes. Four substitutions have been obtained, but in none has the deleterious effect been eliminated. All four apparently involve almost an entire arm of the Aegilops chromosome, the

resistance gene evidently being proximally located on this arm. If the deficiency of wheat chromatin involved in any particular substitution proves not to be deleterious when homozygous, further x-ray treatments can presumably be used to break off the unwanted portion of the Aegilops segment.

CYTOGENETIC STUDIES OF STEM SOLIDNESS IN WHEAT

Ruby I. Larson and M. D. MacDonald

Solid stem is one factor in resistance of wheat to the wheat stem sawfly, Cephus cinctus Nort. Three sources of stem solidness are being exploited, S-615, a solid-stemmed variety of Triticum aestivum (n=21); Golden Ball, a variety of T. durum (n=14); and the species Aegilops sharonensis (n=7).

The stem solidness of Golden Ball is more stable than that of solid-stemmed varieties of T. aestivum, and its distribution is different. Golden Ball tends to become hollow at the base in an unfavourable environment whereas S-615 becomes hollow in the top two internodes. Although attempts to transfer solid stem from Golden Ball to T. aestivum by hybridization with hollow-stemmed varieties have failed, there are now over four hundred F_9 lines from the cross Rescue x Golden Ball that are more solid than Rescue. The pattern of pith distribution is, however, typical of T. aestivum. The amphiploid Golden Ball x Aegilops squarrosa is less solid than S-615 and it has the T.aestivum pith pattern, demonstrating the effect of the D genome.

Aneuploid analysis of stem solidness in S-615 (T.aestivum) has shown that most large differences between solid-and hollow-stemmed varieties are due to genes actively inhibiting pith formation. Strong inhibitors have been found on chromosomes XIII, XIX, XX, and XXI. The one (or more) on chromosome XXI is present in S-615 as well as in hollow-stemmed wheats, probably accounting for its instability. Chromosomes I, VIII, IX, X, XI and/ B type XII have fairly small effects, but all appear to promote solidness. It is suggested that the "modifying factors" brought forward to account for results that are not clear-cut are due to differences in "promoting" genes on these chromosomes. On the basis of these findings and those of other workers, it is postulated that chromosomes II, III, IV, V, VI, VII AND XIV belong to the A genome and I, VIII, IX, X, XI, XII, XIII belong to the B genome.

Although T. dicoccoides is thick-walled, hollow, and Aegilops sharonensis has only a small amount of pith, their amphiploid has a fairly solid stem. It's solidness was largely dominant in a cross with Apex (T.aestivum). Only three of the chromosomes of Ae.sharonensis appear to have much homology with the D genome of T. aestivum. One associated with stem solidness appears not to have any. Because genes from T. dicoccoides confused the study, a new project to make alien addition and substitution lines has been started. Red Bobs (T.aestivum) has been crossed with Ae. sharonensis and the chromosome number has been doubled. This amphiploid is to be back-crossed by Red Bobs until the

seven addition lines of one Ae. sharonensis chromosome have been produced. These are to be studied for stem solidness, resistance to powdery mildew and to race 15B of stem rust, and morphological characters. These studies are likely to be confused by homologies between Ae. sharonensis chromosomes and the D genome, but gene transfer would then be facilitated and practical results much easier to obtain.

GLEANINGS FROM STUDIES OF THE McFADDEN-SEARS ALLOHEXAPLOIDS

E. S. McFadden

A study of the McFadden-Sears synthetic allohexaploids involving Aegilops squarrosa and the rust resistant tetraploid wheats shows that in every case, under field conditions, the addition of the C genome has a diluting effect on the genes for resistance to stem rust and leaf rust. This is in agreement with the theory of Karl Sax published in 1923, but it leaves the high resistance of Hope wheat unexplained. In one of our tests, Hope wheat was entirely free from stem rust, Vernal emmer was moderately resistant and the allohexaploid, Vernal x Ae squarrosa, was susceptible. In another test, in the known presence of Race 15B, there was a gradation from moderate resistance in Hope to complete susceptibility in Vernal x Ae. squarrosa. The studies include combinations of Ae. squarrosa with Vernal emmer, Wild emmer, T. timopheevi, and the durum varieties, Iumillo, Pentad, Carleton, Golden Ball and P.I. 54587.

The allohexaploids, Triticum dicoccoides x Aegilops speltoides and T. timopheevi x Ae. speltoides are highly resistant in the field of Races 11 and 15B of stem rust. Some of the free-threshing selections from the back-cross of T. dicoccides x Ae. speltoides with Austin are also highly resistant to the above races. However, all of these resistant selections have certain undesirable characters of Ae. speltoides, and cytological studies show that some of them carry extra chromosomes or chromosome fragments. Nevertheless, their F_1 hybrids with T. vulgare are highly fertile, whereas the F_1 hybrids of the original allohexaploid, T. dicoccoides x Ae. speltoides, with T. vulgare are almost completely sterile.

ANEUPLOID ANALYSES OF THE GENES FOR STEM RUST RESISTANCE AND HEAD DENSITY IN McMURACHY WHEAT

R. F. Peterson and A. B. Campbell

McMurachy wheat was crossed with Chinese spring wheat monosomic for chromosome XX. F_1 plants were cytologically identified as monosomic or disomic, and heads of both types were covered with glassine bags to insure self pollination. F_2 progenies were studied in the greenhouse for seedling reaction to stem rust race 15B. In 306 F_2 seedlings from disomic F_1 plants 24.2% were susceptible, whereas in 396 F_2 seedlings from monosomic F_1 plants 1.3% were susceptible indicating that the main gene for resistance in McMurachy wheat is located on chromosome XX.

Similar F_2 populations were grown to maturity in the field under a rust epidemic involving 15B and various other races. Again there was a marked deficiency of susceptible F_2 plants in progenies of monosomic F_1 plants, confirming the greenhouse findings. The main gene for head density in McMurachy wheat was also found to be located in chromosome XX. Earlier genetic data had shown linkage of the genes for rust resistance and head density.

Previous studies with various monosomic lines other than XX had given negative results.

Tuesday Evening, January 6.

Dr. J. G. Dickson was Chairman of the "Special Section on Chemical Control of Rusts."

J. G. Dickson: Application of fungicides to wheat just before the head emerges tends to protect the upper portions of the plant better than earlier or later applications. Temperature and humidity at the time of application and following it are important factors in the success of fungicidal treatment.

CALCIUM SULFAMATE A PROMISING SYSTEMIC FUNGICIDE FOR THE CONTROL OF STEM AND LEAF RUST OF WHEAT

J. E. Livingston

Calcium sulfamate has shown considerable promise as a systemic fungicide in the control of stem and leaf rust of wheat. It is suitable for aerial application being very soluble in water and apparently non injurious to plants at concentrations sufficiently high to control leaf and stem rust when applied in the field at low volumes. Physiological changes were induced in the plants but as yet these have not been found to be deterimental. Calcium sulfamate acts primarily as an eradicant; however, there are indications that it also limits reinfection to a certain extent.

Discussion:

J. E. Livingston: Calcium sulfamate was one of about 200 compounds to be tested. Phenyl hydrazine and related compounds looked good in the greenhouse, when plants were covered, but apparently were not transported in plants in the field. Calcium sulfamate is absorbed very quickly. An application was made in Mexico several hours before a rain, and gave good control; rust did not develop any further, although there was 65% rust at the time of application, when the plants were in flower. The treatment should not be used except when a rust epidemic threatens, after infection shows in the field. Treated wheat in Nebraska was lighter in color 24 hours after the application.

J. W. Gibler: Calcium sulfamate delayed maturity of the wheat in Mexico.

UNITED STATES DEPARTMENT OF AGRICULTURE
AGRICULTURAL RESEARCH ADMINISTRATION
Bureau of Plant Industry, Soils, and Agricultural Engineering

(Not for Publication)

SUMMARY OF COOPERATIVE FIELD TEST OF FUNGICIDES FOR THE CONTROL OF CEREAL RUSTS, 1952 1/

By CONLEY V. LOWTHER
Division of Cereal Crops and Diseases

Cooperative field tests were started in 1951 in an attempt to evaluate some of the newer fungicides for their effectiveness in controlling cereal rusts. These experiments were continued this year and the results obtained in 1952 are reported here.

The treatments and dosages used for spray and dust applications were as follows:

Treatments 2/	Dust		Spray
	% active Ingredient	Lbs./ Acre	Lbs./100 gal. H_2O/Acre
1 Untreated check			
2 Sulfur	100	40	
3 Zineb (Zinc ethylene bisdithiocarbamate)	5.2	40	1 1/2
4 Manzate (Manganese ethylene bisdithiocarbamate)	5.2	40	1 1/2
5 Phygon XL (2,3-dichloro-1, 4 naphthoquinone)	4.0	40	1/4
6 Calcium sulfamate	15.0	40	4-6
7 Orthocide (N-trichloromethyl thio-tetrahydrophthalimide)			2

Significant data are presented in table 1. As was the case in 1951, no treatment was outstanding in all respects at all locations. Perhaps manzate and zineb should be rated as the best treatments in 1952 when everything is considered. Calcium sulfamate was the most active compound. It gave excellent control of rust at some locations, but caused severe injury in many tests.

1/ Cooperative experiments conducted by members of the Division of Cereal Crops and Diseases, United States Department of Agriculture, State Agricultural Experiment Stations, the Rockefeller Foundation in Mexico and the Dominion Laboratory of Plant Pathology, Winnipeg, Manitoba.

2/ Phygon XL was supplied by Naugatuck Chemical, Orthocide by California Spray-chemical Corporation and the other fungicides by E. I. du Pont de Nemours and Company.

Plant Industry Station
Beltsville, Md.
249CC-January 1953

Table I. Significant Stem and Leaf Rust Readings and Yield Data from the Uniform Tests for Fungicidal Control of Cereal Rusts.

	Winnipeg, Canada		Fargo, N. D.	Manhattan, Kansas			Madison, Wisc.	State College, Mississippi			Urbana, Illinois 2/			Gainesville, Fla. 2/	Quincy, Fla. 2/
	Yield Bu./ acre	Bu. wt./ lbs.	Yield/ gms.	Leaf	Yield Bu./ acre	Bu. wt./ lbs.	Stem 1/	Leaf	Stem	Yield Bu/ acre	Crown	Yield Bu./ acre	Bu. wt./ lbs.	Bu/acre 3/	Bu/acre 4/
Check	16.6	49.6	121.5	65.0	60.1	61.4	14.4	90	27	40.1	100	64.5	23.6	5.1	31.6
Sulfur	32.1	59.0	121.4	10.0	61.2	61.8	11.0	28	1.8 R	38.6	25	68.0	24.4	7.6	39.3
Zineb (dust)	37.5	61.1	112.6	22.5	59.4	62.0	11.3	27	11.8	41.2	100	64.9	24.1	13.7	48.1
" (spray)	36.9	59.8	152.6	20.0	63.1	61.6	15.5	12.4	T	39.3	100	65.3	24.1		
Manzate (dust)	28.7	56.9	131.6	6.3	53.7	62.0	9.3	20	6	42.7	100	70.7	25.2	14.6	54.7
" (spray)	27.1	54.2	134.8	30.0	57.9	61.9	12.4	11	T	37.5					
Phygon (dust)	26.2	54.6	98.6	52.5	47.7	61.4	6.7	29	11	42.1	100	72.5	24.1		
" (spray)	20.9	51.2	112.4	57.5	62.8	62.0	15.0	22	2.4	41.4	50	63.1	23.5		
Ca. Sulf. (dust)	15.2	52.7	107.6	37.5	49.2	60.9	15.8	5.2 I	3	35.8	40 R	74.1	26.0		
" (spray)			113.4	T	43.5	52.8	15.2	T R	T R	5.0					
Orthocide (spray)				50.0	63.8	62.0									

1/ L.S.D. 4.15
2/ Oats
3/ L.S.D. 8.4
4/ L.S.D. 5.4

A short summary of the results obtained at each cooperating station follows:

<u>Winnipeg, Canada</u> (B. Peturson, T. Johnson)

Five applications of fungicides were applied at weekly intervals. The final ones were made on July 26-28, but the treated plants were not ripe until August 20-27. Thus the protection afforded the plants earlier in the season lapsed and all plots showed considerable rust infection at the time of harvest. Zineb was the outstanding treatment. In readings made August 5, zineb (dust and spray) treated plots averaged 3% stem rust while the untreated plots averaged 41%. Sulfur gave almost as much protection; these plots had only 5% rust. There was no significant difference between the rust readings made on September 3, but the early protection is apparently reflected in the increased yields which are given in table 1. Calcium sulfamate caused considerable leaf injury.

<u>Gainesville and Quincy, Florida</u> (R. W. Earhart)

Sulfur, zineb and manzate dusts were compared for effectiveness in controlling crown rust of oats and leaf rust of wheat. There was adequate rust for good tests at Gainesville and Quincy. As shown in table 1, both zineb and manzate were significantly better than the check in terms of yield of oats at both stations. There was no significant difference between treatments on wheat.

<u>Urbana, Illinois</u> (W. M. Bever)

Two applications of the fungicides indicated in table 1 were used to test for their control of crown rust of oats. Sulfur, phygon (spray) and calcium sulfamate were the only treatments that reduced the rust infection, but there was no significant difference in yield between treatments. The test weights for manzate and calcium sulfamate, however, were significantly better than the check. Some leaf injury was caused by sulfur, zineb (dust) and phygon (spray).

<u>Manhattan, Kansas</u> (C. O. Johnston, W. C. Haskett)

Three applications of fungicides were made. There was no significant increase in yield with any treatment, however, the percentage of leaf rust was considerably reduced with sulfur, zineb and manzate dusts and zineb and calcium sulfamate sprays. The calcium sulfamate spray was the most outstanding treatment from the standpoint of rust control. It reduced leaf rust to a trace, but caused a highly significant reduction in yield and test weight. Phygon and calcium sulfamate dusts caused a significant reduction in yield.

<u>Mexico</u> (N. E. Borlaug)

No report received.

<u>State College, Mississippi</u> (T. E. Summers)

All fungicides gave some measure of control of both stem and leaf rust as shown in table 1, but none produced significant yields above that of the check. Possibly had the rust developed earlier, greater differences would have been obtained. Calcium sulfamate

spray caused a significant reduction in yield. These plots did not ripen normally and none of the grain was of usuable quality.

St. Paul, Minnesota (M. N. Levine)

A preliminary report only has been received. The seasonal average infection in untreated plots was 54.4% for leaf rust and 47.9% for stem rust. The lightest seasonal infection appeared in the plots treated with calcium sulfamate, averaging 25% leaf rust and 25.4% stem rust. Manzate gave somewhat less control (leaf rust 32% and stem rust 29.4%). Sulfur appeared to be the least effective in controlling the severity of the two epidemics (41.7% leaf rust and 41.9% stem rust).

Fargo, North Dakota (W. E. Brentzel)

Variations in yield were considerable, but cooperator did not believe they were significant. They were due in part to the fact that the stands were not uniform, but some differences appeared to be due to the different fungicides. Differences in test weights from the various plots were small. Phygon caused slight leaf injury.

Denton, Texas (I. M. Atkins)

No rust appeared in plots, hence no fungicides applied.

Madison, Wisconsin (J. G. Dickson)

Two applications of fungicides were made. The average of the stem rust readings for the lower stem and neck of culm are given in table 1. The manzate and phygon XL dusts were significantly better than the check.

A. Campos: Calcium sulfamate was applied to plots two times, a week apart. Unsprayed check plots were killed by rust, but the sprayed plots developed only 40% rust. There did not seem to be any injury from the application. Yields were not determined. Treated wheat was a darker green than unsprayed wheat in Mexico.

N. E. Borlaug: The effectiveness of Calcium sulfamate under Mexican conditions can be appreciated only when it is realized that it rains practically every day there when the wheat is maturing, and any dust treatment is washed off very rapidly.

CHEMICAL CONTROL OF CEREAL RUSTS

M. N. Levine

The field studies carried out at St.Paul during 1951 and 1952 have not thus far yielded sufficiently positive results to warrant the use of fungicides as practical means of controlling rust epidemics, at least insofar as Marquis wheat at this particular locality is concerned. The following fungicides were used in 1951: Sulforon (100% wettable sulfur), Ferbam (6.1% ferric dimethyl dithiocarbamate, Zineb (5.2% zinc ethylene bisdithiocarbamate), Manzate (6% manganese ethylene bisdithiocarbamate), Phygon XL (4% 2,3-dichloro-1, 4-naphthoquinone), Ammate (8% ammonium sulfamate), and Orthocide (8% N-trichloro-methylthio-tetrahydrophthalimide). Five weekly dustings were applied to quadruplicate plots at the rate of 40 lbs. per acre, beginning June 18th and ending July 16th.

Manzate was most effective in the control of leaf rust, Phygon in that of stem rust. The untreated plots averaged a seasonal leaf rust load of 63.6% and a final average stem rust score of 42.5%, the corresponding averages in the Manzate treated plots were 21.0% and 33.8%, and those for Phygon were 36.7% and 28.8%. The advantages obtained from Manzate dusting over the untreated plots consisted of 23.9% increase in yield, 1 lb/bu improvement in test weight, and 26.2% increase in monetary value. Phyon treatments yielded 10.9% higher producitivity, nearly 1 lb/bu better test weight, and 12.8% added monetary value. However, even the higher gains that resulted from the use of Manzate were barely enough to cover the market price of the dust, let alone the cost of labor.

In 1952, five instead of seven fungicide dusts were used. These were as follows: Sulforon)97% wettable sulfur), Zineb (8% zinc ethylene bisdithiocarbamate), Manzate (8.2% manganese ethylene bisdithiocarbamate), Phygon XL (4% 2,3-dichloro-1, 4-naphthoquinone), and Calfamate (15% calcium sulfamate). The applications again were at the rate of 40 lbs. per acre, five during the growing season at weekly intervals. First dusting was made on June 7th, the day after leaf rust made its initial appearance in the test plots; stem rust was first detected on

June 23rd. The leaf rust epidemic of 1952 appeared to be considerably less severe at the final reading than what it was at the corresponding juncture in 1951. The average seasonal load, however, was measurably more so. Stem rust, on the other hand, was a good deal more severe this past year than it was the year before. Soil and weather conditions were less favorable in 1952. Yields were poorer, kernels lighter and smaller, test weights lower.

The plots treated with Calfamate, although scoring the least severe infection of either stem or leaf rust, produced the lowest yield and poorest return though not the lightest nor smallest kernels or poorest test weight. This was evidently due to the toxic effect of the chemical, causing considerable injury to the leaves and thereby interfering with the normal photosynthetic activities of the plants. Phygon did not do as well as either Calfamate or Manzate insofar as infection severity control is concerned, but its plots produced the highest yield, heaviest kernels, and best estimated monetary value. But even so, the improvement over the untreated plots was a mere 9% in yield, a 1.2 lbs/bu better test weight, and a 10.2% higher return per acre. The fungicide treatments of 1952 proved even much less economical than they were the preceding year.

Tuesday evening, January 6.

Dr. G. A. Ledingham was Chairman of the "Special Section on Physiology of Parasitism of Rusts".

P. K. Isaac: Studies recently initiated in the Department of Botany at the University of Manitoba are concerned with the physiology of germinating rust spores. The effect of the physical nature of the substrate is being investigated, as well as the effects of chemicals in the environment.

F. R. Forsyth: We are trying to work out methods of lyophilizing large quantities of rust spores for long-term storage. One of our projects will be the study of rust enzymes, using the Warburg apparatus. Another one will be to try to work out the nutritional requirements of rust, by using the paper chromatographic technique to follow the changes in Khapli which has been made susceptible to rust by treatment with DDT.

J. G. Dickson: Rust spore germination has been studied at Madison. There is evidence of the production of a volatile substance that inhibits germ tube elongation under certain conditions. The development of new techniques and new equipment may make it possible to surmount difficulties that thwarted earlier investigators, in working out the physiology of the rusts, and trying to grow them on synthetic media.

G. A. Ledingham: Attempts are being made at the Prairie Regional Laboratory to grow rusts in artificial culture. A large number of chemicals have been used, with no success so far. Tissue cultures of various higher plants have been established, in the hope that rusts may be grown on the cultures as a preliminary step in establishing them on non-living substrates.

Wednesday morning, January 7.

Dr. Glenn S. Smith was Chairman of the morning session on "Other Objectives".

OBSERVATIONS ON WHEAT BREEDING IN SOUTH AMERICA

C. H. Goulden

Observations made in Brazil, Uruguay, Argentina, Chile, Peru and Colombia.

In Brazil wheat breeding is going on at Bage, Campinas and Pelotas. The most extensive work is that at Pelotas under the direction of Professor da Silva. Wheat rust races present at Pelotas include 11, 15, 17, and 42. At present 17 is the most widely distributed race. Definite progress is being made in the production of resistant varieties.

Wheat breeding for Uruguay is concentrated at La Estanzuela under the direction of Dr. Gustavo J. Fischer. Dr. Fischer finds that it is essential in the breeding program to use parents that are adapted agronomically to the area.

Wheat breeding in the Argentine is concentrated at Buenos Aires, Pergamino, and the Klein estancia. The Department of Immunology at the Instituto Fitotecnico in Buenos Aires combines the breeding and plant pathology aspects of the control of plant diseases. They also act as a service organization for other plant breeders and plant pathologists. At Pergamino a large amount of work is being done with flax and excellent progress has been made in breeding for wilt and rust resistance. Enrique Klein, private plant breeder, has produced most of the varieties now being grown in the Argentine. He has full scale breeding and testing equipment.

The Chile Department of Agriculture has wheat breeding at the Experiment Station at Paine which is just outside of Santiago. The work is directed by Sr. René Cortazar. The races of stem rust present on the Pacific Coast are mainly 11, 15, 17, and 14. Canadian varieties are being used successfully here as rust resistant parents.

In Peru the wheat breeding is being done at La Molina which is on the outskirts of Lima. Dr. A. F. Swanson is acting as advisor on behalf of the United States Government in its Point Four Program. There was a

heavy epidemic of stem rust in the nursery and definite evidence of the presence of 15B.

The Colombia wheat program is directed by Dr. J. A. Rupert where the work is supported by the Rockefeller Foundation. Varieties being grown by farmers are much too late and a new early, rust resistant variety known as Menkamen has already been produced.

RESISTANCE TO LODGING AND SHATTERING AND EARLY MATURITY AS IMPORTANT CONSIDERATIONS IN MEXICAN BREEDING PROGRAM

Norman E. Borlaug and Federico Castillo

LODGING

Resistance to lodging has become much more important during the past two years in Mexico. Prior to 1950 the only area where this factor was of importance was on the new lands being brought under irrigation in Sonora. The great majority of wheat in Mexico, up until that time, was being grown on lands of extremely low fertility. Most of this land had been cultivated continuously for several hundred years without the benefit of legumes, animal manure, or chemical fertilizers. Plant development and yields in these areas were exceedingly poor, yields of 7 to 8 bushels per acre were common, which is very low for irrigated wheat.

When chemical fertilizers became available at a reasonable price for the first time two years ago, many farmers began applying them to their wheat with excellent results. However, with this change, it was essential to plant varieties which were resistant to lodging where heavy fertilization was being practiced if optimum yields were to be obtained.

Fortunately during the early years of the breeding program resistance to lodging had been an important consideration in Sonora and short, strong strawed varieties had been developed or selected for that area i.e. Yaqui, Mayo, Gabo. The demand for varieties with these characteristics continues to develop, in other areas, as use of chemical fertilizers increases.

All of the original "native" Mexican varieties, were very susceptible to lodging when grown under conditions of medium to high fertility. The varieties Gabo, Timstein, Marroqui 588, Ramona 44 and Mentana have all been helpful in improving the resistance to lodging in the Mexican Breeding program. Many of the varieties and lines which have Timstein, Gabo or Marroqui in their pedigree are short and stiff-strawed and very resistant to lodging. Although many lines which are developed from crosses with Mentana are very short, they have somewhat brittle straw and are more susceptible to lodging under severe conditions. All of the Brazilian varieties are very tall and weak strawed, and in virtually all cases the best lines developed from crosses with these wheats, have been unsatisfactory because of their susceptibility to lodging.

All of the commercial Argentine varieties have the same defects.

Virtually all of the commercial Northern hard red spring wheat varieties of the United States and Canada are tall and susceptible, or moderately susceptible to lodging when grown under irrigation in Mexico. Perhaps Lee and Newthatch are somewhat less susceptible to lodging than the other standard varieties of this group.

Shattering

Resistance to shattering is becoming more important in Mexico as mechanization of harvest becomes more important. During the main harvesting season in most areas, extremely low relative humidities are encountered, accompanied by strong winds. These two factors greatly contribute to shattering. These conditions are most accentuated in Sonora where varieties which are susceptible to shattering cannot be grown successfully. If susceptible varieties are grown experimentally in that area, it is very common to have from 40 to 60% of the grain on the ground five days after the crop is mature enough for combine harvesting.

In breeding for resistance it is necessary to develop varieties that combine strong glumes and a strong rachis - some varieties may have one or these characteristics, but may be deficient in the other. The following varieties have been used to combine these characteristics.

A. Varieties Resistant to Shattering (Strong Glumes).

1. Maria Escobar - Peru
2. General Urquiza - Argentina
3. Pelon Colorado - Mexico
4. Candeal - Mexico
5. Aguilera - Mexico
6. Kenya 324 - Mexico

B. Varieties with Strong Rachis.

1. Kenya 324
2. Gabo
3. Newthatch
4. Renown

As a result of crosses between these two groups, lines have been isolated which combine the best characteristics of the two groups. Perhaps the two best combinations are found in the two crosses:

1). (Aguilera x Kenya) x (Marroqui x Supremo) cross II-1088
2). Kenya x General Urquiza cross II-1121 and II-1122

Although these two crosses in themselves have other defects which have made them unsatisfactory as commercial varieties they are being

extensively used as parents in our crossing program at the present time.

Early Maturity as an Important Consideration in the Development of Mexican Wheat Varieties.

The amount of water available for irrigation is the primary factor which limits Mexican wheat production. Therefore with a given amount of water available for irrigation, it is necessary to develop varieties which will produce the maximum amount of grain. Varieties such as Yaqui, Chapingo, Mayo and Lerma, are generally 10 to 17 days earlier maturing than the varieties which they replaced. These newer varieties will significantly outyield the old varieties even though they receive one less irrigation than the later maturing varieties. Consequently, the saving in water represented by one irrigation can be used to increase the area planted to wheat. Moreover by developing early rust resistant varieties which mature before frosts, it is now possible to cultivate wheat successfully in the mountain valleys above 6,000 feet during the rainy season.

The best sources of earliness for the conditions of short days such as are encountered in Mexico are:

A. Bread Wheat Varieties:

1). Marroqui - Morroco
2). Ramona - California
3). Mentana - Italy
4). Gabo - Australia
5). Timstein - "
6). Reward - Canada

All of the United States and Canadian wheats with the exceptions noted above are extremely late when grown in Mexico.

B. Durum wheats:

1). Ethiopia St464
2). Barrigon Yaqyu (Triticum turgidum). Many of the Triticum turgidums from the world collection are 14 to 21 days earlier in the U. S. Durum varieties.

SPRING FROST RESISTANCE

L. H. Shebeski

Rust, as a periodic menace to the production of bountiful crops, has been given a considerable amount of attention. There is complete agreement that rust resistant varieties give the farmers of the Great Plains area much needed protection. In the more northerly regions where spring wheat is commonly grown, another hazard periodically takes a toll, and I now speak of the damage caused by spring frost.

In 1950 a severe spring frost completely destroyed the variety

Rescue in many fields in Saskatchewan so that reseeding was necessary. Thatcher in the same fields (Rescue being grown as a sawfly guard strip around Thatcher) made good recovery.

In a plant breeding program the breeder could select more effectively from a group of similar lines if he had some means of differentiating the lines for spring frost resistance. This would necessarily involve artificial tests because spring frosts are not sufficiently timely or regular in occurrence.

Recently, three temperature control chambers were built for use by the Field Husbandry Department, University of Saskatchewan. A year of preliminary testing was done to try and establish the conditions necessary to test varieties of cereal crops for spring frost resistance.

The procedure which we found to give a satisfactory differential in spring frost resistance in wheat is as follows: In flats $3\frac{1}{2}$ x $14\frac{1}{2}$ x $16\frac{1}{2}$ inches, 10 rows of wheat at 25 seeds per row are planted. Two outside rows are border rows, two rows are checks and six rows are for varietal testing. When the plants are in the two-leaf stage, the flats are placed in a hardening chamber at around 35°F. For two successive nights before freezing, The flats are returned to the greenhouse during the day. On the morning following the second night of hardening, the flats are taken directly from the hardening chamber and placed in the freezing chamber where the plants are exposed to 15° of frost for six hours. The flats are then returned directly to the greenhouse where the temperature is approximately 55°F. A survival count is made five to six days later.

The survival count is made by observing every plant within the rwo and giving each plant a survival index value as follows:

0 - if plant is completely killed.
1 - if both leaves are killed but plant still alive as determined by a fresh appearance of the plant about an inch from the soil surface.
2 - If one leaf is killed and part of a second one killed or damaged.
3 - if only one leaf is killed and second one untouched.
4 - If plant is untouched and shows no frost damage.

The checks used are Thatcher as resistant and Reward as susceptible. In sixteen tests the mean survival of Thatcher was 44.3% and of Reward was 22.8%. The standard error for a mean difference of 21.5% was $\pm$ 1.71%. Reward was used as the susceptible check rather than Rescue because in the preliminary trials, Reward was found to be even more susceptible than Rescue.

Discussion:

Question: Are you sure that when Rescue wheat appeared to be wiped out

it was really killed?

L. H. Shebeski: Yes. Plants do not have to be killed to be damaged. Even plants that recover may be injured. Yields were reduced by 15% as a result of spring frosts in 1926.

N. M. Grant: The sawfly resistant varieties appear to be most susceptible to spring frost. How does Chinook behave under experimental conditions?

L. H. Shebeski: We have tested only our own hybrids, so I do not know.

N. E. Borlaug: We have had frosts, and have noticed differences in reaction of varieties. Turgidum-type wheats are highly susceptible to frost at all stages of growth.

Glenn S. Smith: We have noticed that early varieties are injured more easily by frost. Perhaps the growing point may be more exposed in early varieties.

J. B. Harrington: Frost reaction depends a lot on the genes. Varieties with large doses of winter wheat in their ancestry had good frost resistance. Hope and its derivatives tend to be susceptible.

P. J. Olson: We have dissected barley plants which appeared completely frozen and found the growing points uninjured.

RESISTANCE TO AFTER-HARVEST SPROUTING

J. B. Harrington

Notwithstanding the great importance of rust resistance in varieties of wheat used in Saskatchewan resistance to other crop hazards is also needed in these varieties. Resistance to after-harvest sprouting is an important attribute of a wheat variety in those regions where prolonged moist weather conditions may occur at harvest. The resistance of a variety to harvest sprouting is measured by its after-ripening or dormancy period. Our simplified testing procedure was published in 1949 in Scientific Agriculture.

The varieties of wheat in the 1952 tests showed a range from one which germinated 100% within four days after having been stored dry for ten days to another which showed only 22% germination when exposed to conditions favoring germination for four days after thirty days of dry storage. Five of our Comet-Apex-Thatcher hybrid lines showed the longest dormancy. All but one of the other varieties, including Rescue, Thatcher, Chinook, Lee and Apex, were intermediate in length of dormancy. The dormancy testing procedure reveals the low dormancy varieties quite clearly, but shows less clearly which varieties have the longest dormancy.

We now desire to determine the limitations of the procedure

under different environmental conditions with a view to devising improved tests to use in our wheat breeding program. The main purpose of such tests will be, as in the case of our present tests, the insuring of a reasonable degree of dormancy in any variety we release for general farm use. We have 14 million acres of wheat in Saskatchewan each year and produce half the wheat of Canada. In the past we have in some years lost many millions of bushels of wheat from sprouting in the stook or swath. If through breeding we can reduce sprouting losses to only a half or a third of what they have averaged in the past, we automatically save for the farmers directly, and most everybody else, indirectly, a total of two or three million dollars a year.

DESIGN TECHNIQUES AND TESTING

C. H. Goulden

In cereal breeding it is emphasized that the technique of selection should vary with the efficiency with which characters can be selected. The general principle is that characters which can be selected with high efficiency should be selected for in F_2 and F_3 keeping the hybrid population on a single plant basis with large numbers. Characters of low selection efficiency such as yield and quality should be selected for only after homozygous lines have been produced. It is suggested that the first yield and quality tests should be on large numbers of units in a test of a preliminary nature. As the number of units is reduced, the number of replications and size of plot can be increased until the regular rod-row test is reached.

In bringing forward a large number of homozygous lines it is suggested that use could be made of growth chambers allowing of the production of 4 or 5 generations per year.

Discussion:

L. H. Shebeski: Does Dr. Goulden reduce the number of F_2 plants in making his selections?

R. F. Peterson: Yes, but every F_2 plant is represented in F_6 and F_7.

Major Strange: Would it be desirable to have more than your present 23 tests?

R. F. Peterson: No, we get a good evaluation with 23, and it would be a lot of work to increase the number.

A. M. Schlehuber: Could you decrease the number on the basis of correlation between certain stations?

R. F. Peterson: It would be difficult.

W. C. Broadfoot: By using three soil zones don't you come up with varieties that are adapted to each area?

R. F. Peterson: Yes. Provincial Committees issue detailed recommendations on the varieties to grow in various parts of their respective provinces.

PRELIMINARY SEED PROCESSING

A. B. Masson

New cereal varieties, in the early stages of testing, are rarely in a highly pure state. As the testing advances, the plant breeder selects certain varieties that have sufficient promise to warrant work on the development of pure seed stocks.

The procedure at Winnipeg has been to begin processing when the variety has been one year in the Co-operative Tests conducted by the Associate Committee on Plant Breeding. When varieties are eliminated the corresponding processed stocks are also eliminated. During the testing period (3 years) a small increase of the unprocessed stock is carried along until it is established that the purification is a success. If all has gone well there will be available a small supply of reasonably pure seed (100 pounds to 10 bushels) and a somewhat larger supply of impure seed (10-50 bushels).

If the variety is approved, a license is applied for and more extensive multiplication of the pure stock begins. Sometimes, stocks are multiplied in the impure state, but this is only done when a variety is urgently required and it is not desirable to hold back the distribution until fully purified stock is available.

For discussion the procedures can be conveniently divided into three stages:

1. The production of Breeder Seed (in Canada Foundation Stock)
2. Preliminary increasing
3. Multiplication and distribution to farmers

The Production of Breeder Seed

In the first year of advanced testing we select 200 to 500 heads from the original stock. The following year head rows are grown, and these are examined several times during the growing season. If a head row throws a single major off-type it is discarded. The processor must decide the tolerance of harmless inherent off-types he will allow and this would have to be within the limit set as to the norm for the variety by the plant breeder. Lines which throw a greater percentage of minor types than permissible would be discarded. Lines may be discarded for other reasons than the production of major and minor off-types, for example, low vigor, poor general appearance, an apparently high incidence of susceptibility to one or more diseases, and poor kernel characteristics. The remaining head rows are harvested as lines and two typical heads are taken from each line.

An equal amount of seed of each line is sown in progeny plots and a head row corresponding to each progeny plot is grown the same year.

The second head of each line is retained in storage as a reserve. Single or double ten-foot rows or rod rows of each line are grown in a disease nursery for the purpose of checking the reaction to the major diseases such as stem rust and smut. Discarding is done on the same basis as the year before, and if a progeny plot is discarded for any reason the corresponding head row is also discarded.

The above procedure is continued until the progeny plots are considered to be sufficiently uniform for bulking as stock seed.

Head rows provide seed for the following year's progeny plots, and progeny plots are always bulked for stock seed. Only under exceptional circumstances would the seed from bulked progeny plots be increased before release as Breeder Seed.

It is important to grow the progeny plots in more than one location, because differences due to soil and climate bring our differences between the lines that otherwise would not be observed. This is accomplished by growing the progeny plots on the farm of a co-operator and also by growing the lines in disease nurseries at Winnipeg.

Preliminary Increasing

When a variety approaches the stage where it seems probable that it will be satisfactory, the first increase takes place either at an Experimental Station or on the farm of a co-operator. This might be made from Breeder Seed or unprocessed seed. If unprocessed seed is used, processing will go on at the same time. The increase usually requires about two years. The amount of seed supplied to any one co-operator will depend on the total seed supply and the area of clean land available. Usually co-operators receive from a few pounds to a few bushels.

The total quantity of seed from these initial increases will vary from 1,000 to 3,000 bushels. This seed is sold to growers who enter into contracts for the final increase. If the variety is discarded at this stage, the farmer co-operator is allowed to dispose of the increase as commercial grain.

Multiplication and Distribution to Farmers

The supply of seed obtained from the preliminary increase is increased again by Experimental Farms and farmer co-operators under contract. The seed produced by contract growers is distributed to farmers and it is usual to limit the amount supplied to each farmer.

SAWFLY RESEARCH

M. N. Grant

The weatern wheat stem sawfly, Cephus cinctus Nort., is indigenous to the North American continent. With the development of wheat farming on a large scale, the insect moved from prairie grasses to wheat, causing losses estimated as high as 20,000,000 bushels annually

in Canada prior to 1946.

The morphological character most consistently associated with sawfly resistance is solid stem. Platt, et al, concluded that three factor pairs are involved in the expression of solidness, the solid condition resulting when all three pairs are in the recessive condition, Solid-stemmed varieties of Triticum vulgare, notably line S-615, have been used in the development of sawfly-resistant commercial bread wheats, e.g. Rescue and Chinook. Chinook is superior to Rescue in milling and baking characteristics.

Cytological studies by Larson have identified several chromosomes as carriers of genes associated with stem solidness. It is postulated that the B genome carries genes promoting solidness, and the D genome carries inhibitors which are epistatic to the promoters. Most hexaploid wheats therefore tend to be hollow.

The expression of stem solidness is affected by environmental conditions during May and June. Light intensity is probably the main environmental character affecting solidness.

Unfortunately, only the S-615 type of resistance is now available in commercial bread wheats. Other types of resistance being used in the breeding program are the solid-stemmed durum varieties, and solid-stemmed lines of Agropyron elongatum. Other sources of resistance are being sought in the World Wheat Collection.

Within Canada the Project Group on Breeding Spring Wheats for the Prairie Region brings to bear on the problem the assistance of plant breeders from several stations, plant pathologists, entomologists, plant physiologists, cereal chemists and cytogeneticists. International cooperation has been informal but very satisfactory. Uniform sawfly nurseries are now grown at Lethbridge, Alberta, Minot, North Dakota, and Choteau, Montana.

WHEAT STEM SAWFLY

C. W. Farstad

Nature of Resistance

Sawfly resistance in the present varieties is associated with stem solidness. Solidness in itself is apparently the most important characteristic but varieties and lines that appear to be equally solid differ in degree of resistance. The more susceptible varieties also differ in degree of resistance.

Breakdown of Resistance

Stem solidness is not a stable characteristic and, under certain environmental conditions, is reduced with a corresponding loss of resistance. In the eastern part of the great plains, which is also the area of greatest rust hazard, solidness and sawfly resistance are

reduced. In this area increased sawfly resistance must be associated with rust resistance.

Races of Sawfly

There is evidence that there are physiologic races of wheat stem sawfly. Selected strains from the eastern portion of the great plains (Regina plains) reacted differently from strains from western Alberta in some solid-stemmed varieties.

Varietal Influence of Wheat Stem Sawfly

Sex Ratio

Sawfly progeny from different wheat varieties differ significantly in sex ratio. This phenomenon is not explainable on the basis of differential mortality. Female sawflies are diploid and males haploid. Controlled fertilization by females is a possibility.

Femal Size and Fecundity

Female sawflies reared from a large series of wheat varieties showed significantly marked differences in both total length and oviposition potential.

Variety	Average Length of Female	No. of eggs
S-615 x Coronation	6.7	24
Rescue	6.9	27
S-615	7.0	29
Golden Ball	7.2	31
Thatcher	7.4	37
Mindum	7.7	38
Apex	8.0	43
Marquis	8.0	45

Adaption to Winter Wheat

In Alberta and Montana winter wheat has been attacked just as severely as spring wheat. Until recent years the winter wheat varieties seemed to escape serious infestation.

Natural and Cultural Control

In certain areas, especially the northern and eastern portions of the sawfly-infested areas, native parasites have been effective in preventing serious build-up since 1942. There is some evidence of increasing infestation in 1953.

Cultural control can be successfully demonstrated but it has never been extensively accepted as it involved careful timing of opera-

tions, crop rotation planning, and some carefully planned tillage work, not necessarily additional operations.

COOPERATIVE SAWFLY PROJECT IN MONTANA

F. H. McNeal

One of the main objectives of the winter and spring wheat breeding programs in Montana is to develop wheats which possess resistance to the wheat stem sawfly (Cephus cinctus Nort.). This insect first began to cause alarm in Northeastern counties and the Western part of the Triangle in Montana in 1941. Since 1941, the sawfly has become a major pest of both winter and spring wheat. While principal areas of infestation are still in the Northeastern counties and in the Triangle area, there is evidence that areas of infestation are increasing in size. A general eastward movement in the Dutton area is evident and reports of damage from the Judith Basin are becoming more frequent.

All work pertaining to wheat stem sawfly in Montana is cooperative between the Montana Agricultural Experiment Station, the Bureau of Plant Industry, Soils and Agricultural Engineering and the Bureau of Entomology and Plant Quarantine. When this cooperative project was initiated in 1948, the first objective was a screening for sawfly resistance of the entire wheat collection maintained by the Bureau of Plant Industry, Soils and Agricultural Engineering. A second objective was the incorporation of any new sources of resistance into wheats acceptable to the producer and industry.

With the end of harvest in 1952 some 6,500 different spring wheat varieties and selections and about 3,400 winter wheat varieties and selections have had at least a preliminary screening for sawfly resistance. The preliminary screening has been carried out by growing a single 5-foot row of each variety and recording amount of cutting at harvest time. Those entries with low cutting percentages, in comparison to check varieties, have been harvested and planted in replicated plots for re-testing the following year.

Preliminary tests with winter wheats have produced no satisfactory results to date. Lack of winter hardiness of these wheats has been a detriment in obtaining sawfly cutting notes, but even so, no winter wheat has been found which shows suitable resistance to sawfly. About 140 winter wheats were saved from preliminary tests in 1949, but subsequent tests have shown that none of these have satisfactory resistance. Therefore, it appears that to obtain resistance in winter wheats it may be necessary to transfer it from resistant spring wheats.

Preliminary tests with spring wheats have produced more favorable results although no wheat with immunity to sawfly attach has been found. Over 200 spring wheats were re-tested in 1952 and of this group, 53 were harvested for further tests. Of these 53 wheats, two originated in India, one in Russia, one in Turkey and the remaining 49 in Portugal. Most of these wheats show some degree of stem solidness indicating that resistance to sawfly is no doubt associated with this plant

character. In fact, no hollow stemmed vulgare wheat has been tested in Montana which has shown resistance to sawfly over a period of years. This fact indicates that it may be difficult to find a wheat with physiclogical resistance. Since the present source of resistance to the wheat stem sawfly is associated with stem solidness this might cause one to suppose that the resistance plant breeders are presently working with is purely mechanical.

Prior to 1951 the only vulgare wheat being used as a source of resistance in the breeding program in Montana was Rescue, which derives its solidness of stem from S-615, a wheat from Portugal. However, since 1951, 10 wheats from Portugal have been used in crosses with Lee, Thatcher and Rescue. Since most of these crosses were made in 1952 it is proposed that the crossed seed will be grown in the greenhouse to provide F_2 seed for planting in the spring of 1953.

In the breeding program no difficulty has been encountered in recovering the stem solidness of Rescue. However, some difficulty has been encountered in obtaining selections with earliness of maturity and satisfactory quality. During short growing seasons Rescue is too late for satisfactory combine harvest, so one of the present objectives of the breeding program in Montana is to combine earliness of maturity with other desirable characteristics in a spring wheat for sawfly areas.

The more advanced sawfly resistant spring wheat lines being considered derive their resistance from Rescue and these have been in yield trials at various Montana Stations from one to three years. At the present time, two wheats, namely N1764 (Pilot x Merit) x Rescue, B49-90 and Rescue x Thatcher, B50-18 are considered the most promising from an agronomic and quality standpoint. A third line, N1750 (Pilot x Mida) x Rescue, B49-102 has desirable agronomic characteristics but quality data in 1952 was unfavorable. These three wheats have been about equal to Rescue in yield and test weight, but with the exception of B49-102, their quality ratings have been superior. These three wheats are being increased at Brawley, California this winter to provide seed for larger plot tests in 1953.

The stem solidness of Rescue is presently being used as a source of sawfly resistance in the winter wheat breeding program. The more advanced material from this program consists of 17 lines from the cross Yogo and Rescue. These 17 lines were advanced to replicated yield trials for seeding in the fall of 1952. Previous tests indicate that the stem solidness of Rescue has been recovered in these lines but there is some doubt if the winter hardiness of Yogo has likewise been recovered.

In 1948, Dr. E. R. Hehn of the Montana Agricultural Experiment Station made crosses with some of the Yogo x Rescue lines and Wasatch, Karkoff and Yogo. Selections from these crosses are being continued in a sawfly infested area near Choteau, Montana.

Summary

Briefly stated, the sawfly population in many Montana Counties appears to have reached the point where favorable environment and the proper host plants provide for rapid increase and consequently severe losses. Therefore, it seems necessary that producers be continually encouraged to grow resistant varieties and employ tillage methods which will tend to decrease the sawfly population

BREEDING WHEAT FOR THE SAWFLY AREA IN NORTH DAKOTA

R. M. Heermann

Attention has been directed toward screening and testing foreign introductions in search of new sources of resistance to the wheat stem sawfly. Since 1949 approximately 4500 common wheat varieties and 900 durums were screened at Minot, North Dakota in cooperation with the Bureau of Entomology and Plant Quarantine. Of 2490 varieties in the C. I. Collection first grown in 1949 only three varieties showed resistance throughout three years of testing. These were C.I. 6060, C.I. 6068 and C.I. 11702. All three of these are very similar in appearance, have solid stems, and are about equal to Rescue in resistance. Their degree of resistance and solidness is influenced by environment much as it is in Rescue. Only one other common wheat has been found so far that shows promise as a new source of resistance. This is P.I. 170924, an introduction from Africa which is a late maturing, hollow stemmed variety. Eggs are laid and hatch in this variety but the survival of the larva is low. Stem cutting in 1951 was only 9 percent compared with 25 for Rescue, 89 for Mida and 80 for Thatcher. During the season when larval counts were being made, dead larva were very common in this variety. More tests are needed to learn how useful this variety may be. Eighteen durum varieties appeared promising for resistance after the 1951 tests.

Date of planting tests were grown in 1949 and 1951 to determine what merit delayed seeding might have in the control of sawfly losses. In both years infestation was found to be highest in the earliest seedings which were made during the last few days of April. The later seedings were made at one week intervals during May. Infestation was lower in the delayed plantings but the difference was not sufficient to compensate for the reduction in yield associated with delayed seeding.

The most advanced breeding material is from crosses of Ceres, Thatcher, N.1764, N.1850, N.2157, and Mida with Rescue. None of these crosses can provide adequate resistance to leaf or stem rust, but they may produce a variety having the sawfly resistance of Rescue combined with yield and quality comparable to Thatcher or Mida under North Dakota conditions. In 1951 crosses were made for the purpose of combining leaf rust resistance and sawfly resistance using Lee, N.2211, Ns. 3654 and Ns.3681 for leaf rust resistance and Rescue and Chinook

for sawfly resistance. In 1950 and again in 1952 stem rust infection was quite heavy at the Minot station. This means that an improved wheat variety for much of the sawfly area in North Dakota must have resistance to stem and leaf rust as well as to sawfly if it is to be of value in that area. During the last summer, several crosses were made for the purpose of combining 15B resistance with sawfly resistance.

Discussion:

Question: Is there any sawfly resistance in Kenya wheats?

R. M. Heermann: We had one Kenya wheat which showed low sawfly infestation in 1950, but in 1951 infestation was quite heavy on it. None of the wheats was free in 1951.

Major Strange: Can we find more wheat varieties with solid stems anywhere in the world?

B. B. Bayles: We have a good representation of wheats from all over the world and have sent most of them to be tested against sawfly. We have old varieties from Russia, but none from there since sometime in the 1930's.

A. M. Schlehuber: Some of the lines of *Agropyron elongatum* have sawfly resistance. The winter types have thick straw. Any one who is interested can have some seed.

REPORT OF THE SPECIAL SECTION ON GENETICS, ANEUPLOIDS, AND SPECIES BUILDING IN WHEAT

Ruby I. Larson

Resistant varieties are the plant breeder's answer to the rust problem. But adaptive evolution of the rust organism makes it a never ending task to locate and to incorporate into good varieties, needed resistance. As the number of resistance factors needed becomes greater, the breeder's work becomes more difficult. Genetic analysis is needed to discover where the genes for resistance can be obtained, how they interact with one another and with other factors of the genetic background, and to suggest to the plant breeder new techniques for effectively and economically combining required factors.

Aneuploid analysis (chiefly monosomic and nullisomic) has already located eight genes for stem rust resistance on six different chromosomes and one for leaf rust resistance. Monosomics are available now for all chromosomes in the variety Chinese Spring and are being produced in at least ten others. They include wheats of winter and spring habit, red and white kernel color and hard and soft kernel types--when completed these test aneuploids should extend considerably the range of these studies. Aneuploid analysis can yield information not obtainable through conventional genetic methods.

When adequate resistance genes cannot be found in wheat, related species of grass are exploited. Sometimes these must be combined with others to build new species (amphiploids) which will form fertile hybrids with wheat. Transfer of the desired gene may then be accomplished as a result of Mendalian crossing over with a wheat chromosome. If this does not occur, alien addition or substitution of the critical chromosome, with or without subsequent irradiation, may be resorted to. More new sources of resistance need to be discovered and their amphiploids tested.

As all these fields of study, when carried out on an adequate scale, require an enormous amount of work, every effort should be made to disseminate information when obtained, thus preventing unnecessary duplication of effort.

Discussion:

W. M. Myers: The analysis of genetic factors is extremely complex, but this type of research is essential in developing varieties carrying a high degree of resistance to any or all races of rust. We were very much impressed by the large amount and excellent quality of this work being done in Canada. We are not doing our share of this kind of work in the United States.

Ruby Larson: Dr. Sears has been very generous in supplying workers in Canada with his material. We have been given every opportunity to pursue this work.

REPORT OF THE SPECIAL SECTION ON STEM RUST CONTROL WITH CHEMICALS

J. G. Dickson

Applying fungicidal sprays for the control of stem rust has been only partly successful. Most of the compounds tested function as protective agents. It is economically impractical to keep all of the young leaf surface covered with the fungicide to prevent infection. It is difficult to get the fungicide down into the leaf whorl for early protection of the young plant tissue. Some of the compounds possible for use decompose when exposed to light. The fungicide to be effective must be absorbed by the plant and conducted to the new leaf and stem tissue as they develop.

Some of the nonsystemic compounds have been successful in controlling stem rust when applied during the late leaf-whorl stage of plant development. Securing good coverage of the differentiated tissues enclosed in the leaf whorl prior to spike emergence combined with persistence of the compound has given good control of stem rust during the past two years. The control depends upon covering those tissues before the rust inoculum is established. These compounds represent several chemical groups such as the naphthoquinones, the phenols and the carbamates.

Systemic fungicides nontoxic to man and animal represent the best means of control, but these are not yet available on a practical, economical basis. Enough success has been obtained to urgently demand further research.

Arrangements have been made for screening compounds for phytotoxic action and rust control.

Discussion:

J. Unrau: Has the use of antibiotics against stem rust been investigated?

J. G. Dickson: Yes. We considered the antibiotics among the chemicals.

E. C. Stakman: We should continue the search for new materials. Those that have been found promising should be tested under different environmental conditions. The Division of Cereal Crops and Diseases have offered to supply materials. Dr. Lowther should be notified by all those who wish to cooperate in this work, so that arrangements can be made.

REPORT OF SPECIAL SECTION ON PHYSIOLOGY OF PARASITISM OF RUSTS

C. A. Ledingham

Recently projects have been started in several laboratories in both the United States and Canada on various phases of this very broad problem. In Canada the Department of Agriculture has made grants to various departments of the three Prairie Universities to study physiological and biochemical problems of the rusts and their hosts. Dr. Isaac was recently appointed to the Dept. of Botany, University of Manitoba, and Dr. Forsyth, a plant physiologist, was appointed to the Rust Laboratory in Winnipeg. Each of these men outlined work he planned on undertaking. Dr. Shaw in plant physiology at Saskatoon, has also received assistance to undertake a project on the rusts but he was unable to attend this meeting.

Dr. Dickson, from the University of Wisconsin outlined a few projects they have undertaken in connection with enzymology and chemistry of spore germination. He mentioned the study of a volatile factor which inhibits spore germination.

Following these speakers, there was considerable discussion on various phases of the biochemistry of parasitism. Dr. Meredith, Dr. McCalla, Dr. Hanna, Dr. Johnson and Dr. Stakman all pointed out the necessity for supporting more work of a fundamental nature in this field. Dr. Stakman indicated that some of the difficulties in obtaining government support in this type of fundamental work but stressed the importance of carrying it on. The meeting closed with a recommendation that all interested in the rust problem should strongly support the need for more physiological, ecological and biochemical studies being carried out to help clarify and simplify the complex situation in which pathologists and cereal breeders find themselves at present.

Wednesday afternoon, January 7.

Dr. B. B. Bayles and Dr. W. F. Hanna were co-chairmen of the session on "Future Plans".

B. B. Bayles: Will those wheat breeders who have particularly promising breeding material to include in the select nursery of 500 to 600 varieties with the "cream" of the world collection, please send in as soon as possible 150 grams of each variety to be put into the nursery.

Please send in as soon as possible any suggestions, and seed, for the group of about 100 varieties to evaluate the resistance of specific genes against specific races of rust. Will those who plan to test this group of 100 varieties against specific rust races in the greenhouse please give their names to Dr. Ausemus.

Dr. Borlaug has been testing from 3,000 to 4,000 lines, including some early generation material, each year in the summer nursery in Mexico. Seed is not harvested, except resistant plants in segregating lines. Please let me know if you wish to have any material tested in this nursery, as Dr. Borlaug has asked that all U. S. material be sent as one group. Anyone in Canada who wants to send down material, may do so through Dr. T. Johnson or Dr. R. F. Peterson.

What should be the policy in connection with the use of 15B in field nurseries? If plant breeders are not able to test their lines in local nurseries, they must make arrangements for having them tested elsewhere.

E. C. Stakman: 15B is present throughout the area now. We must still be careful in timing field inoculations, to avoid the possibility of spreading rust to commercial fields. Races or biotypes not common in the area should NOT be put out in the field. Such collections are sent out only for greenhouse inoculations, with specific instructions against putting them out in the field. They should be used in the greenhouse at a time of year when escape from the greenhouse to the field cannot occur.

D. G. Fletcher: The growers and industry accept the need for testing new varieties under extreme conditions. But there is real danger in putting out particularly virulent or rare races or biotypes, particularly in the southern part of the country. Workers in each area must consider the consequences of their trials, in the area to the north of them where the rust might spread. It might be well to wait until rust appears naturally in the field before making inoculations. Test plots might be sown late, to get better results from such late inoculations. The cooperation of the governments of Canada, the United States, Mexico, and the South American countries, should be enlisted, so that new varieties could be put out for test at field stations in appropriate places.

E. C. Stakman; H. A. Rodenhiser: There are many factors to be considered. It is up to the appropriate authorities in individual states, to decide whether or not inoculations should be made in the field.

J. G. Dickson: I am going to express my own opinion, and I hope that it concurs with that of my colleagues. This has been an outstanding meeting. At the informal meeting of 1924, the problems were similar to those discussed here. These subjects have expanded and become more involved, however. This three-day meeting has given us more basic, fundamental material to think about, as well as practical information. Out of this meeting have evolved challenges in genetics, cytology, plant physiology, and chemistry as applied in this field of biology, which go far beyond the problem of stem rust. We are now dealing as an international group with problems which involve the major bread crop of the western hemisphere. I would like to have us expand the concept of this meeting to deal with wheat in all its aspects.

To me the meeting has been most stimulating, and illustrates the need for concentrating a research group on a single problem for greatest accomplishment. We should try to meet again in two years, in Mexico if possible. We should see some of the phenomenal things described by Dr. Borlaug. I therefore suggest that we take this possibility under consideration in planning the next international meeting of what I would like to call the Wheat Conference.

I should like to acknowledge the work of the secretaries, Mr. Heermann and Dr. Sackston, and of Miss Watkins.

H. A. Rodenhiser: I should like to thank the officials of the Canada Department of Agriculture and all our co-workers who made this meeting possible. I should also like to vote thanks to the committees that did the preliminary work for this Conference: Dr. R. F. Peterson, Dr. T. Johnson, Dr. W. F. Hanna, Dr. E. C. Stakman, Dr. Helen Hart, Prof. T. E. Stoa, and Dr. E. R. Ausemus. I hope very much that it will be possible to hold a meeting two years hence, and I would be particularly glad to see it held in Mexico. I certainly endorse Dr. Dickson's statement.

K. W. Neatby: I have been very much impressed by the high level of ability of the people doing rust research work. The future success of the work is assured. The cooperation among all the research workers is particularly impressive. If the next meeting is held in Mexico, there may be a fair representation of Canadians there, but it might not be an adequate representation of those doing the actual work.

J. G. Harrar: If the next meeting can be planned for Mexico, I am sure the government of Mexico would most likely extend an invitation to come there. The people at the Rockefeller Foundation would certainly welcome the Conference, and would make the necessary arrangements.

Glenn S. Smith: We have not yet heard from the people in barberry eradication work.

D.G. Fletcher: Wherever rust control is discussed, the role of the barberry must be considered. The origin of new races of rust on barberry has been mentioned repeatedly at this meeting. A very effective barberry eradication program was carried out in Western Canada. Much money has been spent, and a great deal accomplished, in the United States, particularly in the states from Missouri and Nebraska north. Millions of bushes have been eradicated in Pennsylvania and Virginia. The use of new chemicals has made eradication very much easier and cheaper than it used to be. Locating the last few bushes in an area is now the most expensive part of the work. Barberry eradication is progressing satisfactorily, and continues to be an integral part of the rust control program.

B. B. Bayles: This has been one of the most interesting and stimulating meetings I have ever attended.

W. F. Hanna: It is my pleasure to remind you of the very cordial invitations from Dr. Johnson and Dr. Peterson to visit the "Rust Research Laboratory" immediately after the close of this meeting. I declare this meeting adjourned.

ATTENDANCE AT THE WHEAT RUST CONFERENCE, WINNIPEG, CANADA, JANUARY 5, 6, 7, 1953

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